



Quality Assurance Project Plan Addendum

Remedial Investigation/Feasibility Study

**Falcon Refinery Superfund Site
Ingleside, San Patricio County, Texas
EPA Identification No. TXD086278058**

**Remedial Action Contract 2 Full Service
Contract: EP-W-06-004
Task Order: 0088-RICO-06MC**

Prepared for

U.S. Environmental Protection Agency
Region 6
1445 Ross Avenue
Dallas, Texas 75202-2733

Prepared by

EA Engineering, Science, and Technology, Inc.
405 S. Highway 121
Building C, Suite 100
Lewisville, Texas 75067
(972) 315-3922

August 2013
Revision: 00
EA Project No. 14342.88

Quality Assurance Project Plan Addendum

Remedial Investigation/Feasibility Study

**Falcon Refinery Superfund Site
Ingleside, San Patricio County, Texas
EPA Identification No. TXD086278058**

**Remedial Action Contract 2 Full Service
Contract: EP-W-06-004
Task Order: 0088-RICO-06MC**



12 August 2013

Tim Startz, PMP
EA Program Manager

Date



12 August 2013

David S. Santoro, P.E., L.S.
EA Quality Assurance Officer

Date

Brian Mueller
U.S. Environmental Protection Agency Region 6 Task Order Monitor

Date

LIST OF ACRONYMS AND ABBREVIATIONS

AOC	Area of Concern
bgs	Below ground surface
COPC	Contaminant of potential concern
CRQL	Contract-required Quantitation Limit
CSM	Conceptual Site Model
EA	EA Engineering, Science, and Technology, Inc.
EPA	U.S. Environmental Protection Agency
ERA	Ecological risk assessment
FS	Feasibility Study
ft	foot
HHRA	Human health risk assessment
MCL	Maximum contaminant level
NRDA	Natural Resource Damage Assessment
PCB	Polychlorinated biphenyl
PCL	Protective concentration levels
QAPP	Quality Assurance Project Plan
RBEL	Risk-based exposure limits
RI	Remedial Investigation
RSL	Regional screening levels
Site	Falcon Refinery Superfund Site
SSL	Soil screening levels
SVOC	Semi-volatile organic compound
TCEQ	Texas Commission on Environmental Quality
TRRP	Texas Risk Reduction Program
TSS	Total suspended solids
VOC	Volatile organic compound
VSP	Visual Sample Plan

DISTRIBUTION LIST

U.S. Environmental Protection Agency

Name: Michael Pheeny
Title: EPA Region 6 Contracting Officer (Letter Only)

Name: Rena McClurg
Title: EPA Region 6 Project Officer (Letter Only)

Name: Brian Mueller
Title: EPA Region 6 Task Order Monitor

Name: Anna Milburn
Title: EPA Region 6 Ecological Risk Assessor

Name: Kenneth Shewmake
Title: EPA Region 6 Ecological Risk Assessor

Texas Commission on Environmental Quality

Name: Phillip Winsor
Title: Project Manager

Name: Vickie Reat
Title: Ecological Risk Assessor

Other State/Federal Natural Resource Trustees

Name: Jessica White
Title: National Oceanic and Atmospheric Association, RRC Region 6

Name: Clare Lee
Title: U.S. Fish and Wildlife Services (USFWS) Contaminant Biologist

Name: Barry Forsythe
Title: USFWS

Name: Ron Brinkley
Title: USFWS Contaminant Biologist

Name: Don Pitts
Title: Texas Parks and Wildlife Department (TPWD) Program Director

Name: Andy Tirpak
Title: TPWD Natural Resource Damage Assessment (NRDA) Trustee

Name: Jane Sarosdy
Title: Texas General Land Office (TGLO) Director, NRDA Trustee

Name: Tommy Mobley
Title: TGLO Tech. Program Manager

EA Engineering, Science, and Technology, Inc.

Name: Tim Startz
Title: Program Manager (Letter Only Via E-mail)

Name: Robert Owens
Title: Project Manager

Name: File
Title: EA Document Control File

1. PROJECT DESCRIPTION AND MANAGEMENT

EA Engineering, Science, and Technology, Inc. (EA) has been authorized by the U.S. Environmental Protection Agency (EPA), under Remedial Action Contract Number EP-W-06-004, Task Order 0088-RICO-06MC, to conduct a Remedial Investigation/Feasibility Study (RI/FS) at the Falcon Refinery Superfund Site (site). EA has prepared this Quality Assurance Project Plan (QAPP) Addendum to address the changes to the original QAPP submitted to the EPA on 4 February 2012. These changes have been made in accordance with specification provided in the Field Change Form No. 01 and the Technical Exchange Meeting held on 2 May 2013. The screening level criteria tables in Appendix A of the QAPP have been updated and are included in this QAPP Addendum. The Visual Sample Plan (VSP) Reports generated for Area of Concern (AOC) 3 in Appendix B of the QAPP have been updated and are included in this QAPP Addendum. The figures in the QAPP have not changed. Appendices C and D of the QAPP have not changed. The sections of the original QAPP that have changed are discussed below. The section numbers correspond to the section numbers in the original QAPP.

1.2 DESCRIPTION OF PROJECT OBJECTIVES AND TASKS

This section describes the project objectives and tasks for this QAPP.

1.2.1 Project Objectives

The key components for the RI/FS have changed as noted below:

- **Soil Sampling**
 - Onsite and offsite surface and subsurface soil sampling (up to 195 samples) will be collected from surface soil and from subsurface soil from borings installed to approximate depths to 15 feet (ft) below ground surface (bgs) to assess presence of contaminants of potential concern (COPCs) of high toxicity and/or high mobility, define the nature and extent, characterize waste to allow for a disposal option evaluation in the FS, evaluate whether COPCs are migrating offsite, and develop data to be used in the Ecological Risk Assessment (ERA) and Human Health Risk Assessment (HHRA).
 - Surface and subsurface soil samples will be analyzed for volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), and metals. Soil samples will also be analyzed for total organic carbon.
 - Two surface soil samples in AOC 3 will be analyzed for tributyltin compounds.
 - Background soil samples will only be analyzed for metals.
 - Soil samples taken above and below the water table from monitoring well borings will be also be analyzed for particle size, fraction organic carbon, moisture content, specific gravity, wet sieve, and/or Atterberg limits.

- **Ground Water Sampling**

- Onsite (up to 17 samples) and offsite (up to 10 samples) ground water samples will be collected from permanent and temporary monitoring wells to determine the nature and extent of ground water COPCs. Permanent and temporary monitor well data will be used in the HHRA and ERA. Data collected during the onsite ground water investigation will also be used to update the pathway and receptor analysis presented in the conceptual site model (CSM), if necessary.
- Onsite ground water samples will be analyzed for VOCs, SVOCs, and total and dissolved metals.
- Offsite (background) ground water samples will only be analyzed for metals. Filtered samples will be collected for metals analyses, in addition to unfiltered ones.

- **Surface Water and Sediment Sampling**

- Onsite wetlands, intracoastal, and offsite background surface water (up to 33 samples) and sediment (up to 30 samples) investigations will be performed to define the nature and extent of COPCs, provide data to be used in the HHRA and ERA, and to update the pathway and receptor analysis presented in the CSMs, if necessary.
- Onsite sediment and surface water samples will be analyzed for VOCs, SVOCs, and total and dissolved metals.
- Surface water samples will also be analyzed for total suspended solids (TSS). Sediment samples will also be analyzed for acid volatile sulfides/simultaneously extracted metals.
- Offsite sediment and surface water samples will be analyzed for SVOCs and metals. Filtered samples will be collected for metals analyses, in addition to unfiltered ones for surface water.

- **Ecological Characterization**

- An ecological characterization may be conducted if the previous ecological characterization is not of the quality needed for this RI/FS.
- Up to 16 fish tissue samples will be collected and analyzed based on the results of the Screening Level Ecological Risk Assessment. Samples will be analyzed for parameters as directed by EPA, but will likely include lipids, metals, and SVOCs.

1.3 DATA QUALITY OBJECTIVES

1.3.6 Step 5 – Develop the Analytical Approach

1.3.6.2 Action Level Decision Rule

The risk-based screening criteria that will be used to evaluate whether analytical data will be of sufficient quality for risk assessment has been updated as follows:

Human Health Criteria

- Ground Water – Maximum Contaminant Levels (MCLs) (EPA 2012a). If MCLs do not exist for a COPC, then EPA Tapwater Regional Screening Levels (RSLs) (EPA 2012b) will be used for screening. If neither MCLs nor RSLs exist for a COPC, then the applicable Texas Commission on Environmental Quality (TCEQ) Texas Risk Reduction Program (TRRP) Tier 1 Residential Groundwater Protective Concentration Levels (PCLs) (TCEQ 2012) will be used as screening criteria.
- Surface Water – National Recommended Water Quality Criteria (EPA 2012c). If National Recommended Water Quality Criteria do not exist for a COPC, then the applicable TRRP Surface Water Human Health Risk-Based Exposure Limits (RBELs) (TCEQ 2012) will be used as screening criteria.
- Surface Soil (0- to 2-ft bgs) and Sediment (0- to 12-inches bgs) – EPA RSLs for Residential Soil (EPA 2012b). If RSLs do not exist for a COPC, then the applicable TRRP Tier 1 PCLs for Residential Soil less than 0.5 acres (TCEQ 2012) will be used as screening criteria.
- Subsurface Soil (2 ft bgs to water table) – EPA RSLs for Protection of Groundwater (EPA 2012b). If RSLs do not exist for a COPC, then the applicable TRRP PCLs for soil to ground water (TCEQ 2012) will be used as screening criteria.
- Aquatic life (fish samples) – Safety Levels for Fish and Fishery Products Hazards and Controls Guidance – Fourth Edition (FDA 2011).

Ecological Criteria

- Surface water – National Recommended Water Quality Criteria (EPA 2012c). If National Recommended Water Quality Criteria do not exist for a COPC, then the applicable TRRP Surface Water Human Health RBELs (TCEQ 2012) will be used as screening criteria.
- Surface (0- to 2-ft bgs) and Subsurface Soil (2 ft bgs to water table) – EPA Ecological Soil Screening Levels (SSLs; EPA 2012d).
- Sediment (0 to 12-inches bgs) – Benthic protection based on the National Oceanic and Atmospheric Administration Screening Quick Reference Tables values (Buchman 2008). If these values do not exist for a COPC, then the applicable EPA RSLs for Residential Soil (EPA 2012b) will be used as screening criteria. If RSLs do not exist, then the applicable TRRP Tier 1 PCLs for Residential Soil less than 0.5 acres (TCEQ 2012) will be used as screening criteria.

The primary screening levels and contract-required quantitation limits (CRQLs) are provided in Appendix A. Screening levels and CRQLs for ground water, surface water, soil (surface and subsurface), and sediment are presented in Tables A-1, A-2, A-3, and A-4, respectively.

Fish tissue samples will be collected during the Phase II investigation and analyzed for lipids, metals, and SVOCs. The primary screening levels and CRQLs for these analyses are presented in Table A-5 in Appendix A.

1.3.8 Step 7 – Develop the Plan for Obtaining Data

Visual Sample Plan (VSP)

VSP Version 6.3 was rerun for AOC 3. A more standard approach was used than before, as suggested by the EPA during the Technical Exchange Meeting. Previously, VSP was used to compute the minimum sample size using a one-sample *t*-test to discern a difference (“gray region” or delta) of either the absolute value of the difference between the sample mean and the benchmark or one half the sample standard deviation, whichever is greatest, between the mean analyte concentration and its screening level value. The delta for the second run was changed to equal the sample standard deviation.

Delta = $1 \times \text{sample standard deviation}$.

The VSP reports generated for AOC 3 are presented in Appendix B.

2. DATA GENERATION AND ACQUISITION

2.7 ANALYTICAL METHODS REQUIREMENTS

Samples are not being analyzed for polychlorinated biphenyl (PCB), PCB congeners, and herbicides and pesticides. Therefore, Table 4 of the original QAPP has been modified as follows.

TABLE 4 REQUIRED VOLUME, CONTAINERS, PRESERVATIVES, AND HOLDING TIMES

Parameter	Method	Volume and Container	Preservatives	Holding Time ^a
Investigative Solid Samples				
Metals (including mercury)	CLP ISM01.3	One 8-ounce amber glass jar with Teflon™-lined cap	Store at 4±2°C	180 days (28 days for mercury)
VOCs	CLP SOM01.2	Three 5-gram EnCore samplers and One 4-ounce glass jar with Teflon™-lined cap	Store at 4±2°C	48 hours
SVOCs	CLP SOM01.2	One 8-ounce amber glass jar with Teflon™-lined cap	Store at 4±2°C	14 days
AVS/SEM	EPA-121-R91-100	One 4-ounce amber glass jar with Teflon™-lined cap	Store at 4±2°C	14 days
Tributyltin Compounds	GC-FPD	One 4-ounce amber glass jar with Teflon™-lined cap	Store at 4±2°C	14 days

Parameter	Method	Volume and Container	Preservatives	Holding Time ^a
TOC	EPA Method 9060	One 8-ounce amber glass jar with Teflon TM -lined cap	Store at 4±2°C	28 days
Lipids (Fish Tissue)	Modified Bligh Dyer Method or an approved laboratory standard operating procedure.	One 4-ounce amber glass jar with Teflon TM -lined cap	Store at 4±2°C	14 days
SVOCs (Fish Tissue)	SW-846 Method 8270C	One 4-ounce amber glass jar with Teflon TM -lined cap	Store at 4±2°C	14 days
Metals (Fish Tissue)	SW-846 Method 6020 and 7471 (Mercury)	One 4-ounce amber glass jar with Teflon TM -lined cap	Store at 4±2°C	180 days (28 days for mercury)
Moisture Content, Bulk Density, Particle Size (wet), Specific Gravity, Atterberg Limits	ASTM D2216, ASTM D7263, ASTM D422, ASTM D854/C127, ASTM D4318	3-inch diameter Shelby Tube, at least 18 inches long, capped and taped with no headspace	None	None
Fraction Organic Carbon	Walkley-Black	One 8-ounce amber glass jar with Teflon TM -lined cap	Store at 4±2°C	28 days
Investigative Water Samples				
Metals (including mercury)	CLP ISM01.3	One 1-liter HDPE bottle	Nitric acid to Ph ≤ 2; Store at 4±2°C	180 days (28 days for mercury)
VOCs	CLP SOM01.2	Three 40-milliliter amber volatile organic analyte (VOA) glass vials with Teflon TM -lined cap	Hydrochloric acid to Ph ≤ 2; Store at 4±2°C	14 days
SVOCs	CLP SOM01.2	Two 1-liter amber glass bottles	Store at 4±2°C	7 days
TSS	SM 2540 D	One 1-liter HDPE bottle	Store at 4±2°C	7 days
Investigative Soil Vapor Samples				
VOCs	EPA Method TO-15	6-liter Summa canister	None	28 days
Investigation-derived Waste Special Analysis				
Reactivity Corrosivity Ignitability	SW-846 Method 9045C or 9040B, Method 1030, and Chapter 7	One 8-ounce amber glass jar with Teflon TM -lined cap (solid) or one 500-milliliter HDPE bottle (water/sludge)	Store at ≤6°C	NA/72 hours
TCLP metals (including mercury)	SW-846 Methods 1311/6020/6010B/7470A	One 8-ounce amber glass jar with Teflon TM -lined cap (solid) or one 1-liter glass bottle (water/sludge)	Store at ≤6°C	180 days (28 days for mercury)
TCLP VOCs	SW-846 Methods 1311/8260B	One 4-ounce amber glass jar with Teflon TM -lined cap (solid) or Three 40-milliliter amber VOA glass vials with Teflon TM -lined cap (water/sludge)	Store at 4±2°C	14 days
TCLP SVOCs	SW-846 Methods 1311/8270C	One 8-ounce amber glass jar with Teflon TM -lined cap (solid) or one 1-liter glass bottle (water)	Store at 4±2°C	14 days
NOTE:				

Parameter	Method	Volume and Container	Preservatives	Holding Time ^a
<p>a Holding time is measured from the time of sample collection to the time of sample extraction and/or analysis.</p> <p>ASTM = American Society for Testing and Materials</p> <p>°C = degrees Celsius</p> <p>CLP = Contract Laboratory Program</p> <p>GC-FPD = Gas Chromatography – Flame Photometric Detector</p> <p>HDPE = high-density polyethylene</p> <p>NA = Not applicable</p> <p>SVOC = Semi-volatile organic compound</p> <p>TAL = Target Analyte List</p> <p>TBD = To be determined</p> <p>TCLP = Toxicity Characteristic Leaching Procedure</p> <p>TOC = Total organic carbon</p> <p>TSS = Total suspended solids</p> <p>VOA = Volatile organic analyte</p> <p>VOC = Volatile organic compound</p>				

5. REFERENCES

The following references have been added or updated:

Buchman, M.F. 2008. NOAA Screening Quick Reference Tables, NOAA ORR&R Report 08-1, Seattle WA, Office of Response and Restoration Division, National Oceanic and Atmospheric Administration.

Texas Commission on Environmental Quality (TCEQ) 2012. Texas Risk Reduction Program Tier 1 Protective Concentration Levels.

<http://www.tceq.state.tx.us/remediation/trrp/trrppcls.html>. June

U.S. Environmental Protection Agency (EPA) 2012a. National Primary Drinking Water Regulations. <http://water.epa.gov/drink/contaminants/index.cfm>. June.

EPA 2012b. Regional Screening Levels for Chemical Contaminants at Superfund Sites. http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm. May.

EPA 2012c. National Recommended Water Quality Criteria <http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm>

EPA 2012d. Ecological Soil Screening Levels <http://www.epa.gov/ecotox/ecossl/>

United States Food and Drug Administration (FDA). 2011. *Fish and Fishery Products Hazards and Controls Guidance – Fourth Edition*. Department of Health and Human Services. April.

Appendix A

TABLE A-1. REFERENCE LIMITS AND PROJECT ACTION LIMITS FOR GROUNDWATER
FALCON REFINERY SUPERFUND SITE

Analyte	CASRN	Units	c/nc	MCL ¹	TCEQ Residential GW ² GW _{Ing} ²	USEPA Tapwater RSL ³	Applicable Screening Criteria ⁴	Analytical Method*	CLP CRQL
Volatile Organic Compounds									
Acetone	67-64-1	µg/L	nc	NS		12,000	12,000	SOM01.2 Trace VOA	5.0
Benzene	71-43-2	µg/L	c	5.0		0.39	5.00	SOM01.2 Trace VOA	0.5
Bromochloromethane	74-97-5	µg/L	nc	NS		83	83	SOM01.2 Trace VOA	0.5
Bromodichloromethane	75-27-4	µg/L	c	NS		0.12	0.12	SOM01.2 Trace VOA	0.5
Bromoform	75-25-2	µg/L	c	NS		7.9	7.9	SOM01.2 Trace VOA	0.5
Bromomethane (Methyl bromide)	74-83-9	µg/L	nc	NS		7.0	7.0	SOM01.2 Trace VOA	0.5
2-Butanone (Methyl ethyl ketone)	78-93-3	µg/L	nc	NS		4,900	4,900	SOM01.2 Trace VOA	5.0
Carbon disulfide	75-15-0	µg/L	nc	NS		720	720	SOM01.2 Trace VOA	0.5
Carbon tetrachloride	56-23-5	µg/L	c	5.0		0.39	5.00	SOM01.2 Trace VOA	0.5
Chlorobenzene	108-90-7	µg/L	nc	100		72	100	SOM01.2 Trace VOA	0.5
Chloroethane (Ethyl chloride)	75-00-3	µg/L	nc	NS		21,000	21,000	SOM01.2 Trace VOA	0.5
Chloroform	67-66-3	µg/L	c	70		0.19	70	SOM01.2 Trace VOA	0.5
Chloromethane (Methyl chloride)	74-87-3	µg/L	nc	NS		190	190	SOM01.2 Trace VOA	0.5
Cyclohexane	110-82-7	µg/L	nc	NS		13,000	13,000.0	SOM01.2 Trace VOA	0.5
1,2-Dibromo-3-chloropropane (DBCP)	96-12-8	µg/L	c	0.20		0.00032	0.20000	SOM01.2 Trace VOA by SIM	0.050
Dibromochloromethane (Chlorodibromomethane)	124-48-1	µg/L	c	60		0.15	0.15	SOM01.2 Trace VOA	0.5
1,2-Dibromoethane (Ethylene dibromide [EDB])	106-93-4	µg/L	c	0.050		0.0065	0.0500	SOM01.2 Trace VOA by SIM	0.050
1,2-Dichlorobenzene	95-50-1	µg/L	nc	600		280	600	SOM01.2 Trace VOA	0.5
1,3-Dichlorobenzene	541-73-1	µg/L	nc	NS	730	NS	730	SOM01.2 Trace VOA	0.5
1,4-Dichlorobenzene	106-46-7	µg/L	c	75		0.42	75	SOM01.2 Trace VOA	0.5
Dichlorodifluoromethane	75-71-8	µg/L	nc	NS		190	190	SOM01.2 Trace VOA	0.5
1,1-Dichloroethane	75-34-3	µg/L	c	NS		2.4	2.4	SOM01.2 Trace VOA	0.5
1,2-Dichloroethane	107-06-2	µg/L	c	5.0		0.15	5.0	SOM01.2 Trace VOA	0.5
1,1-Dichloroethene	75-35-4	µg/L	c	7.0		260	7.0	SOM01.2 Trace VOA	0.5
1,2-Dichloroethene (cis)	156-59-2	µg/L	nc	70		28	70	SOM01.2 Trace VOA	0.5
1,2-Dichloroethene (trans)	156-60-5	µg/L	nc	100		86	100	SOM01.2 Trace VOA	0.5
1,2-Dichloropropane	78-87-5	µg/L	c	5.0		0.38	5.00	SOM01.2 Trace VOA	0.5
1,3-Dichloropropene (cis)	10061-01-5	µg/L	-	NS	1.7	NS	1.7	SOM01.2 Trace VOA	0.5
1,3-Dichloropropene (trans)	10061-02-6	µg/L	-	NS	9.1	NS	9.1	SOM01.2 Trace VOA	0.5
1,4-Dioxane	123-91-1	ug/L	c	NS		0.67	0.67	SOM01.2 Low VOA	100
Ethylbenzene	100-41-4	µg/L	c	700		1.3	700	SOM01.2 Trace VOA	0.5
2-Hexanone	591-78-6	µg/L	nc	NS		34	34	SOM01.2 Trace VOA	5.0
Isopropylbenzene (Cumene)	98-82-8	µg/L	nc	NS		390	390	SOM01.2 Trace VOA	0.5
4-Methyl-2-pentanone (Methyl isobutyl ketone [MIBK])	108-10-1	µg/L	nc	NS		1,000	1,000	SOM01.2 Trace VOA	5.0
Methyl acetate	79-20-9	µg/L	nc	NS		16,000	16,000	SOM01.2 Trace VOA	0.5
Methylcyclohexane	108-87-2	µg/L	nc	NS	122,210	NS	122,210	SOM01.2 Trace VOA	0.5
Methylene chloride	75-09-2	µg/L	c	5.0		9.9	5.00	SOM01.2 Trace VOA	0.5
Methyl-tertiary-butyl ether (MtBE)	1634-04-4	µg/L	c	NS		12	12	SOM01.2 Trace VOA	0.5
Styrene	100-42-5	µg/L	nc	100		1,100	100	SOM01.2 Trace VOA	0.5
1,1,2,2-Tetrachloroethane	79-34-5	µg/L	c	NS		0.066	0.066	SOM01.2 Trace VOA	0.5

TABLE A-1. REFERENCE LIMITS AND PROJECT ACTION LIMITS FOR GROUNDWATER
FALCON REFINERY SUPERFUND SITE

Analyte	CASRN	Units	c/nc	MCL ¹	TCEQ Residential GW ² GW _{Ing} ²	USEPA Tapwater RSL ³	Applicable Screening Criteria ⁴	Analytical Method*	CLP CRQL
Tetrachloroethene (PCE)	127-18-4	µg/L	c	5.0		9.7	5.00	SOM01.2 Trace VOA	0.5
Toluene	108-88-3	µg/L	nc	1,000		860	1,000	SOM01.2 Trace VOA	0.5
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	µg/L	nc	NS		53,000	53,000	SOM01.2 Trace VOA	0.5
1,2,3-Trichlorobenzene	86-61-6	µg/L	-	NS	NS	NS	NS	SOM01.2 Trace VOA	0.5
1,2,4-Trichlorobenzene	120-82-1	µg/L	nc	70		0.99	70	SOM01.2 Trace VOA	0.5
1,1,1-Trichloroethane	71-55-6	µg/L	nc	200		7,500	200	SOM01.2 Trace VOA	0.5
1,1,2-Trichloroethane	79-00-5	µg/L	c	5.0		0.24	5.0	SOM01.2 Trace VOA	0.5
Trichloroethene (TCE)	79-01-6	µg/L	nc	5.0		0.44	5.0	SOM01.2 Trace VOA	0.5
Trichlorofluoromethane	75-69-4	µg/L	nc	NS		1,100	1,100	SOM01.2 Trace VOA	0.5
Vinyl chloride	75-01-4	µg/L	c	2.0		0.015	2.0	SOM01.2 Trace VOA	0.5
m- & p-Xylenes	179601-23-1	µg/L	-	10,000		190	10,000	SOM01.2 Trace VOA	0.5
o-Xylene	95-47-6	µg/L	-	10,000		190	190	SOM01.2 Trace VOA	0.5
Semivolatile Organic Compounds									
Acetophenone	98-86-2	µg/L	nc	NS		1,500	1,500	SOM01.2 Low SVOA	5.0
Atrazine	1912-24-9	µg/L	c	3.0		0.26	3.0	SOM01.2 Low SVOA	5.0
Benzaldehyde	100-52-7	µg/L	nc	NS		1,500	1,500	SOM01.2 Low SVOA	5.0
1,1-Biphenyl	92-52-4	µg/L	nc	NS		0.83	0.83	SOM01.2 Low SVOA	5.0
Bis(2-chloroethoxy)methane	111-91-1	µg/L	-	NS		47	47	SOM01.2 Low SVOA	5.0
Bis(2-chloroethyl)ether	111-44-4	µg/L	c	NS		0.012	0.012	SOM01.2 Low SVOA	5.0
Bis(2-chloroisopropyl) ether	108-60-1	µg/L	c	NS		0.31	0.31	SOM01.2 Low SVOA	5.0
Bis(2-ethylhexyl) phthalate	117-81-7	µg/L	c	6.0		0.071	6.0	SOM01.2 Low SVOA	5.0
4-Bromophenyl phenyl ether	101-55-3	µg/L	-	NS	0.061	NS	0.061	SOM01.2 Low SVOA	5.0
Butyl benzyl phthalate	85-68-7	µg/L	c	NS		14	14	SOM01.2 Low SVOA	5.0
Carbazole	86-74-8	µg/L	c	NS	46	NS	46	SOM01.2 Low SVOA	5.0
Caprolactum	105-60-2	µg/L	nc	NS		7,700	7,700	SOM01.2 Low SVOA	5.0
4-Chloro-3-methylphenol	59-50-7	µg/L	nc	NS		1,100	1,100	SOM01.2 Low SVOA	5.0
4-Chloroaniline	106-47-8	µg/L	c	NS		0.32	0.32	SOM01.2 Low SVOA	5.0
2-Chloronaphthalene	91-58-7	µg/L	nc	NS		550	550	SOM01.2 Low SVOA	5.0
2-Chlorophenol	95-57-8	µg/L	nc	NS		71	71	SOM01.2 Low SVOA	5.0
4-Chlorophenyl phenyl ether	7005-72-3	µg/L	-	NS	0.061	NS	0.061	SOM01.2 Low SVOA	5.0
Dibenzofuran	132-64-9	µg/L	nc	NS		5.8	5.8	SOM01.2 Low SVOA	5.0
3,3-Dichlorobenzidine	91-94-1	µg/L	c	NS		0.11	0.11	SOM01.2 Low SVOA	5.0
2,4-Dichlorophenol	120-83-2	µg/L	nc	NS		35	35	SOM01.2 Low SVOA	5.0
Diethyl phthalate	84-66-2	µg/L	nc	NS		11,000	11,000	SOM01.2 Low SVOA	5.0
2,4-Dimethylphenol	105-67-9	µg/L	nc	NS		270	270	SOM01.2 Low SVOA	5.0
4,6-Dinitro-2-methylphenol	534-52-1	µg/L	-	NS		1.2	1.2	SOM01.2 Low SVOA	10.0
2,4-Dinitrophenol	51-28-5	µg/L	nc	NS		30	30.0	SOM01.2 Low SVOA	10.0
2,4-Dinitrotoluene	121-14-2	µg/L	nc	NS		0.20	0.20	SOM01.2 Low SVOA	5.0
2,6-Dinitrotoluene	606-20-2	µg/L	c	NS		15	15.00	SOM01.2 Low SVOA	5.0

TABLE A-1. REFERENCE LIMITS AND PROJECT ACTION LIMITS FOR GROUNDWATER
FALCON REFINERY SUPERFUND SITE

Analyte	CASRN	Units	c/nc	MCL ¹	TCEQ Residential GW ² GW _{Ing}	USEPA Tapwater RSL ³	Applicable Screening Criteria ⁴	Analytical Method*	CLP CRQL
Dimethyl phthalate	131-11-3	µg/L	nc	NS	20,000	NS	20,000	SOM01.2 Low SVOA	5.0
Di-n-butyl phthalate	84-74-2	µg/L	nc	NS		670	670	SOM01.2 Low SVOA	5.0
Di-n-octyl phthalate	117-84-0	µg/L	nc	NS	980	NS	980	SOM01.2 Low SVOA	5.0
Hexachlorobenzene	118-74-1	µg/L	c	1.0		0.042	1.0	SOM01.2 Low SVOA	5.0
Hexachlorobutadiene	87-68-3	µg/L	c	NS		0.26	0.26	SOM01.2 Trace VOA	5.0
Hexachlorocyclopentadiene	77-47-4	µg/L	nc	50		22	50	SOM01.2 Low SVOA	5.0
Hexachloroethane	67-72-1	µg/L	c	NS		0.79	0.79	SOM01.2 Low SVOA	5.0
Isophorone	78-59-1	µg/L	c	NS		67	67	SOM01.2 Low SVOA	5.0
2-Methylphenol	95-48-7	µg/L	c	NS		720	720	SOM01.2 Low SVOA	5.0
3- & 4-Methylphenols	15831-10-4	µg/L	c	NS		720	720	SOM01.2 Low SVOA	5.0
2-Nitroaniline	88-74-4	µg/L	nc	NS		150	150	SOM01.2 Low SVOA	10.0
3-Nitroaniline	99-09-2	µg/L	-	NS	7.3	NS	7.3	SOM01.2 Low SVOA	10.0
4-Nitroaniline	100-01-6	µg/L	c	NS		3.3	3.3	SOM01.2 Low SVOA	10.0
Nitrobenzene	98-95-3	µg/L	c	NS		0.12	0.12	SOM01.2 Low SVOA	5.0
2-Nitrophenol	88-75-5	µg/L	-	NS	49	NS	49	SOM01.2 Low SVOA	5.0
4-Nitrophenol	100-02-7	µg/L	-	NS	49	NS	49	SOM01.2 Low SVOA	10.0
N-Nitrosodi-n-propylamine	621-64-7	µg/L	c	NS		0.0093	0.0093	SOM01.2 Low SVOA	5.0
N-Nitrosodiphenylamine	86-30-6	µg/L	c	NS		10	10	SOM01.2 Low SVOA	5.0
Pentachlorophenol	87-86-5	µg/L	c	1.0		0.17	1.00	SOM01.2 Low SVOA by SIM	0.2
Phenol	108-95-2	µg/L	nc	NS		4,500	4,500	SOM01.2 Low SVOA	5.0
1,2,4,5-Tetrachlorobenzene	95-94-3	µg/L	nc	NS		1.2	1.2	SOM01.2 Low SVOA	5.0
2,3,4,6-Tetrachlorophenol	58-90-2	µg/L	nc	NS		170	170	SOM01.2 Low SVOA	5.0
2,4,5-Trichlorophenol	95-95-4	µg/L	nc	NS		890	890	SOM01.2 Low SVOA	5.0
2,4,6-Trichlorophenol	88-06-2	µg/L	c	NS		3.5	3.5	SOM01.2 Low SVOA	5.0
Polycyclic Aromatic Hydrocarbons									
Acenaphthene	83-32-9	µg/L	nc	NS		400	400	SOM01.2 Low SVOA	5.0
Acenaphthylene	208-96-8	µg/L	nc	NS	1,500	NS	1,500	SOM01.2 Low SVOA	5.0
Anthracene	120-12-7	µg/L	nc	NS		1,300	1,300	SOM01.2 Low SVOA	5.0
Benzo(a)anthracene	56-55-3	µg/L	c	NS		0.029	0.029	SOM01.2 Low SVOA by SIM	0.10
Benzo(b)fluoranthene	205-99-2	µg/L	c	NS		0.029	0.029	SOM01.2 Low SVOA by SIM	0.10
Benzo(k)fluoranthene	207-08-9	µg/L	c	NS		0.29	0.29	SOM01.2 Low SVOA by SIM	0.10
Benzo(g,h,i)perylene	191-24-2	µg/L	nc	NS	730	NS	730	SOM01.2 Low SVOA	5.0
Benzo(a)pyrene	50-32-8	µg/L	c	0.20		0.0029	0.20	SOM01.2 Low SVOA by SIM	0.10
Chrysene	218-01-9	µg/L	c	NS		2.9	2.9	SOM01.2 Low SVOA by SIM	0.10
Dibenz(a,h)anthracene	53-70-3	µg/L	c	NS		0.0029	0.0029	SOM01.2 Low SVOA by SIM	0.10
Fluoranthene	206-44-0	µg/L	nc	NS		630	630	SOM01.2 Low SVOA	5.0
Fluorene	86-73-7	µg/L	nc	NS		220	220	SOM01.2 Low SVOA	5.0
Indeno(1,2,3-cd)pyrene	193-39-5	µg/L	c	NS		0.029	0.029	SOM01.2 Low SVOA by SIM	0.10
2-Methylnaphthalene	91-57-6	µg/L	nc	NS		27	27	SOM01.2 Low SVOA	5.0

TABLE A-1. REFERENCE LIMITS AND PROJECT ACTION LIMITS FOR GROUNDWATER
FALCON REFINERY SUPERFUND SITE

Analyte	CASRN	Units	c/nc	MCL ¹	TCEQ Residential GW ² GW _{Ing}	USEPA Tapwater RSL ³	Applicable Screening Criteria ⁴	Analytical Method*	CLP CRQL
Naphthalene	91-20-3	µg/L	c	NS		0.14	0.14	SOM01.2 Low SVOA by SIM	0.10
Phenanthrene	85-01-8	µg/L	nc	NS	730	NS	730	SOM01.2 Low SVOA	5.0
Pyrene	129-00-0	µg/L	nc	NS		87	87	SOM01.2 Low SVOA	5.0
Total Metals *									
Aluminum	7429-90-5	µg/L	-	NS		16,000	16,000	ISM01.3 ICP-MS	20.0
Antimony	7440-36-0	µg/L	nc	6.0		6.0	6.0	ISM01.3 ICP-MS	2.0
Arsenic	7440-38-2	µg/L	c	10		0.045	10	ISM01.3 ICP-MS	1.0
Barium	7440-39-3	µg/L	nc	2,000		2,900	2,000	ISM01.3 ICP-MS	10.0
Beryllium	7440-41-7	µg/L	c	4.0		16	4.0	ISM01.3 ICP-MS	1.0
Cadmium	7440-43-9	µg/L	c	5.0		6.9	5.0	ISM01.3 ICP-MS	1.0
Calcium**	7440-70-2	µg/L	-	NS	NS	NS	NS	ISM01.3 ICP-MS	500
Chromium	7440-47-3	µg/L	nc	100		0.031	100	ISM01.3 ICP-MS	2.0
Cobalt	7440-48-4	µg/L	-	NS		4.7	4.7	ISM01.3 ICP-MS	1.0
Copper	7440-50-8	µg/L	nc	1,300 (action		620	1,300 (action level)	ISM01.3 ICP-MS	2.0
Iron	7439-89-6	µg/L	-	NS		11,000	11,000	ISM01.3 ICP-MS	200
Lead	7439-92-1	µg/L	c	15 (action level)		NS	15	ISM01.3 ICP-MS	1.0
Magnesium**	7439-95-4	µg/L	-	NS	NS	NS	NS	ISM01.3 ICP-MS	500
Manganese	7439-96-5	µg/L	-	NS		320	320	ISM01.3 ICP-MS	1.0
Mercury	7439-97-6	µg/L	nc	2.0		0.63	2.0	ISM01.3 CVAA	0.20
Nickel	7440-02-0	µg/L	nc	NS		300	300	ISM01.3 ICP-MS	1.0
Potassium**	7440-09-7	µg/L	-	NS	NS	NS	NS	ISM01.3 ICP-MS	500
Selenium	7782-49-2	µg/L	nc	50		78	50	ISM01.3 ICP-MS	5.0
Silver	7440-22-4	µg/L	nc	NS		71	71	ISM01.3 ICP-MS	1.0
Sodium**	7440-23-5	µg/L	-	NS	NS	NS	NS	ISM01.3 ICP-MS	500
Thallium	7440-28-0	µg/L	nc	2.0		0.16	2.0	ISM01.3 ICP-MS	1.0
Vanadium	7440-62-2	µg/L	nc	NS		78	78	ISM01.3 ICP-MS	5.0
Zinc	7440-66-6	µg/L	nc	NS		4,700	4,700	ISM01.3 ICP-MS	2.0

TABLE A-1. REFERENCE LIMITS AND PROJECT ACTION LIMITS FOR GROUNDWATER
FALCON REFINERY SUPERFUND SITE

Analyte	CASRN	Units	c/nc	MCL ¹	TCEQ Residential GW ² GW _{Ing}	USEPA Tapwater RSL ³	Applicable Screening Criteria ⁴	Analytical Method*	CLP CRQL
<p>Notes:</p> <p>* Analytical methods were chosen based on the action level for the analyte in an attempt to ensure the CRQL is lower than the action level.</p> <p>** These compounds are not necessarily of concern from a human health standpoint, therefore calculation of human health-based values is not required. However, aesthetics and ecological criteria would still apply. See table entitled "Compounds for which Calculation of a Human Health PCL is Not Required" available on the TCEQ website at http://www.tceq.state.tx.us/remediation/trrp/trrp.htm.</p> <p>CRQLs in red cells are above the action level</p> <p>c - carcinogenic; nc - noncarcinogenic</p> <p>¹ National Primary Drinking Water Regulations MCLs accessed at http://water.epa.gov/drink/contaminants/index.cfm#List in June 2012.</p> <p>² TCEQ TRRP Table 3 Tier 1 Groundwater PCLs Residential, Commerical, and Industrial, June 29, 2012</p> <p>³ Regional Screening Levels (RSLs) (November 2012) as presented at USEPA website at http://www.epa.gov/region9/superfund/prg/</p> <p>⁴ The applicable screening criteria is the MCL. If no MCL exists, the action level is the USEPA Tapwater RSL. If no EPA RSL exists, then the TCEQ Residential GW value is the action level.</p> <p>µg/L = microgram(s) per liter</p> <p>CASRN = Chemical Abstracts Service Registry Number</p> <p>CLP = Contract Laboratory Program</p> <p>CRQL = contract required quantitation limit</p> <p>CVAA = cold vapor atomic absorption</p> <p>EPA = U.S. Environmental Protection Agency</p> <p>ICP-MS = inductively copuled plasma-mass spectrometry</p> <p>MCL = Maximum Contaminant Level</p> <p>NA = not applicable</p> <p>NS = not specified</p> <p>RSL = Regional Screening Levels</p> <p>SIM = selective ion monitoring</p> <p>SVOC = semivolatile organic compound</p> <p>TCEQ = Texas Commission of Environmental Quality</p> <p>TRRP = Texas Risk Reduction Program</p> <p>VOC = volatile organic compound</p> <p>USEPA = U.S. Environmental Protection Agency</p>									

TABLE A-2. REFERENCE LIMITS AND PROJECT ACTION LIMITS FOR SURFACE WATER,
FALCON REFINERY SUPERFUND SITE

Analyte	CASRN	c/ne	Units	TCEQ Surface Water Risk Based Exposure Limits (^{SW} RBEL) ¹						National Recommended Water Quality Criteria ²					Applicable Screening Criteria ³	Analytical Method*	CLP CRQL
				Aquatic Life Freshwater Acute	Aquatic Life Freshwater Chronic	Aquatic Life Saltwater Acute	Aquatic Life Saltwater Chronic	Human Health Water and Fish	Human Health Fish Only	Aquatic Life Freshwater Acute	Aquatic Life Freshwater Chronic	Aquatic Life Saltwater Acute	Aquatic Life Saltwater Chronic	Human Health for Consumption Organism Only			
Volatile Organic Compounds																	
Acetone	67-64-1	nc	µg/L	607,400	101,200	1,692,000	282,000	NS	NS	NS	NS	NS	NS	NS	101,200	SOM01.2 Trace VOA	5.0
Benzene	71-43-2	c	µg/L	NS	130	NS	109	5	513	NS	NS	NS	NS	51	51	SOM01.2 Trace VOA	0.5
Bromochloromethane	74-97-5	nc	µg/L	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	SOM01.2 Trace VOA	0.5
Bromodichloromethane	75-27-4	c	µg/L	12,962	2,160	NS	NS	10.2	322	NS	NS	NS	NS	17	17	SOM01.2 Trace VOA	0.5
Bromoform	75-25-2	c	µg/L	897	149	7,320	1,220	69.1	2,175	NS	NS	NS	NS	140	140	SOM01.2 Trace VOA	0.5
Bromomethane (Methyl bromide)	74-83-9	nc	µg/L	660	110	3,600	600	47	1,500	NS	NS	NS	NS	1,500	1,500	SOM01.2 Trace VOA	0.5
2-Butanone (Methyl ethyl ketone)	78-93-3	nc	µg/L	254,420	42,400	NS	NS	13,932	1,500,000	NS	NS	NS	NS	NS	13,932	SOM01.2 Trace VOA	5.0
Carbon disulfide	75-15-0	nc	µg/L	700	105	NS	NS	NS	NS	NS	NS	NS	NS	NS	105	SOM01.2 Trace VOA	0.5
Carbon tetrachloride	56-23-5	c	µg/L	NS	9.8	NS	1,500	4.1	29	NS	NS	NS	NS	1.6	1.6	SOM01.2 Trace VOA	0.5
Chlorobenzene	108-90-7	nc	µg/L	NS	64	NS	105	100	5,201	NS	NS	NS	NS	1,600	1,600	SOM01.2 Trace VOA	0.5
Chloroethane (Ethyl chloride)	75-00-3	nc	µg/L	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	SOM01.2 Trace VOA	0.5
Chloroform	67-66-3	c	µg/L	5,340	890	24,500	4,100	70	7,143	NS	NS	NS	NS	470	470	SOM01.2 Trace VOA	0.5
Chloromethane (Methyl chloride)	74-87-3	nc	µg/L	165,000	28,000	81,000	13,500	NS	NS	NS	NS	NS	NS	NS	13,500	SOM01.2 Trace VOA	0.5
Cyclohexane	110-82-7	nc	µg/L	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	SOM01.2 Trace VOA	0.5
1,2-Dibromo-3-chloropropane (DBCP)	96-12-8	c	µg/L	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	SOM01.2 Trace VOA	0.5
Dibromochloromethane (Chlorodibromomethane)	124-48-1	c	µg/L	771	129	NS	NS	7.6	239	NS	NS	NS	NS	13	13	SOM01.2 Trace VOA	0.5
1,2-Dibromoethane (Ethylene dibromide [EDB])	106-93-4	c	µg/L	NS	NS	NS	NS	0.16	2.13	NS	NS	NS	NS	NS	0.16	SOM01.2 Trace VOA by SIM	0.050
1,2-Dichlorobenzene	95-50-1	nc	µg/L	660	110	591	99	600	4,336	NS	NS	NS	NS	1,300	1,300	SOM01.2 Trace VOA	0.5
1,3-Dichlorobenzene	541-73-1	nc	µg/L	153	85	855	142	473	1,445	NS	NS	NS	NS	960	960	SOM01.2 Trace VOA	0.5
1,4-Dichlorobenzene	106-46-7	c	µg/L	660	110	597	99	75	190	NS	NS	NS	NS	190	190	SOM01.2 Trace VOA	0.5
Dichlorodifluoromethane	75-71-8	nc	µg/L	11,780	1,963	NS	NS	NS	NS	NS	NS	NS	NS	NS	1,963	SOM01.2 Trace VOA	0.5
1,1-Dichloroethane	75-34-3	c	µg/L	15,370	2,570	NS	NS	NS	NS	NS	NS	NS	NS	NS	2,570	SOM01.2 Trace VOA	0.5
1,2-Dichloroethane	107-06-2	c	µg/L	37,700	6,300	33,900	5,650	5	553	NS	NS	NS	NS	37	37	SOM01.2 Trace VOA	0.5
1,1-Dichloroethene	75-35-4	c	µg/L	9,100	1,500	75,000	12,500	7	23,916	NS	NS	NS	NS	7,100	7,100	SOM01.2 Trace VOA	0.5
1,2-Dichloroethene (cis)	156-59-2	nc	µg/L	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	SOM01.2 Trace VOA	0.5
1,2-Dichloroethene (trans)	156-60-5	nc	µg/L	66,000	22,000	NS	NS	100	10,000	NS	NS	NS	NS	10,000	10,000	SOM01.2 Trace VOA	0.5
1,2-Dichloropropane	78-87-5	c	µg/L	11,200	1,870	NS	2,400	5	226	NS	NS	NS	NS	15	15	SOM01.2 Trace VOA	0.5
1,3-Dichloropropene (cis)	10061-01-5	-	µg/L	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	SOM01.2 Trace VOA	0.5
1,3-Dichloropropene (trans)	10061-02-6	-	µg/L	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	SOM01.2 Trace VOA	0.5
1,4-Dioxane	123-91-1	c	µg/L	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	SOM01.2 Low VOA	100
Ethylbenzene	100-41-4	c	µg/L	6,540	1,090	1,494	249	700	7,143	NS	NS	NS	NS	2,100	2,100	SOM01.2 Trace VOA	0.5
2-Hexanone	591-78-6	nc	µg/L	36,790	6,130	NS	NS	NS	NS	NS	NS	NS	NS	NS	6,130	SOM01.2 Trace VOA	5.0
Isopropylbenzene (Cumene)	98-82-8	nc	µg/L	1,530	255	NS	NS	NS	NS	NS	NS	NS	NS	NS	255	SOM01.2 Trace VOA	0.5
4-Methyl-2-pentanone (Methyl isobutyl ketone [MIBK])	108-10-1	nc	µg/L	158,100	26,400	369,000	61,500	NS	NS	NS	NS	NS	NS	NS	26,400	SOM01.2 Trace VOA	5.0
Methyl acetate	79-20-9	nc	µg/L	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	SOM01.2 Trace VOA	0.5
Methylcyclohexane	108-87-2	nc	µg/L	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	SOM01.2 Trace VOA	0.5
Methylene chloride	75-09-2	c	µg/L	66,000	11,000	32,500	5,420	5	5,926	NS	NS	NS	NS	590	590	SOM01.2 Trace VOA	0.5
Methyl-tertiary-butyl ether (MtBE)	1634-04-4	c	µg/L	66,043	11,000	NS	NS	NS	NS	NS	NS	NS	NS	NS	11,000	SOM01.2 Trace VOA	0.5
Styrene	100-42-5	nc	µg/L	7,515	1,250	2,730	455	NS	NS	NS	NS	NS	NS	NS	455	SOM01.2 Trace VOA	0.5
1,1,2,2-Tetrachloroethane	79-34-5	c	µg/L	2,790	465	2,706	451	3.2	76	NS	NS	NS	NS	4.0	4.0	SOM01.2 Trace VOA	0.5
Tetrachloroethene (PCE)	127-18-4	c	µg/L	4,700	790	8,700	1,450	5	49	NS	NS	NS	NS	3.3	3.3	SOM01.2 Trace VOA	0.5
Toluene	108-88-3	nc	µg/L	8,700	1,450	2,850	480	1000	15,000	NS	NS	NS	NS	15,000	15,000	SOM01.2 Trace VOA	0.5
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	nc	µg/L	1,239	207	NS	NS	NS	NS	NS	NS	NS	NS	NS	207	SOM01.2 Trace VOA	0.5
1,2,3-Trichlorobenzene	87-61-6	nc	µg/L	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	SOM01.2 Trace VOA	0.5
1,2,4-Trichlorobenzene	120-82-1	nc	µg/L	309	51.5	135	22.5	35	70	NS	NS	NS	NS	70	70	SOM01.2 Trace VOA	0.5
1,1,1-Trichloroethane	71-55-6	nc	µg/L	14,700	2,450	9,400	1,560	200	956,663	NS	NS	NS	NS	NS	200	SOM01.2 Trace VOA	0.5
1,1,2-Trichloroethane	79-00-5	c	µg/L	5,400	900	1,650	275	5	295	NS	NS	NS	NS	16	16	SOM01.2 Trace VOA	0.5
Trichloroethene (TCE)	79-01-6	nc	µg/L	¹³ 3,331	¹¹ 555	¹⁰ 5,800	¹⁰ 970	5	649	NS	NS	NS	NS	30	30	SOM01.2 Trace VOA	0.5
Trichlorofluoromethane	75-69-4	nc	µg/L	5,225	871	NS	NS	NS	NS	NS	NS	NS	NS	NS	871	SOM01.2 Trace VOA	0.5
Vinyl chloride	75-01-4	c	µg/L	16,900	2,820	NS	NS	0.25	24	NS	NS	NS	NS	2.4	2.4	SOM01.2 Trace VOA	0.5
m-Xylene	108-38-3	-	µg/L	NS	1.8	NS	NS	NS	NS	NS	NS	NS	NS	NS	1.8	SOM01.2 Trace VOA	0.5
Xylenes	1330-20-7	-	µg/L	4,020	1,340	2,500	850	NS	NS	NS	NS	NS	NS	NS	850	SOM01.2 Trace VOA	0.5
Semivolatile Organic Compounds																	

TABLE A-2. REFERENCE LIMITS AND PROJECT ACTION LIMITS FOR SURFACE WATER,
FALCON REFINERY SUPERFUND SITE

Analyte	CASRN	c/hc	Units	TCEQ Surface Water Risk Based Exposure Limits (^{SW} RBEL) ¹						National Recommended Water Quality Criteria ²					Applicable Screening Criteria ³	Analytical Method*	CLP CRQL
				Aquatic Life Freshwater Acute	Aquatic Life Freshwater Chronic	Aquatic Life Saltwater Acute	Aquatic Life Saltwater Chronic	Human Health Water and Fish	Human Health Fish Only	Aquatic Life Freshwater Acute	Aquatic Life Freshwater Chronic	Aquatic Life Saltwater Acute	Aquatic Life Saltwater Chronic	Human Health for Consumption Organism Only			
Acetophenone	98-86-2	nc	µg/L	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	SOM01.2 Low SVOA	5.0
Atrazine	1912-24-9	c	µg/L	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	SOM01.2 Low SVOA	5.0
Benzaldehyde	100-52-7	nc	µg/L	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	SOM01.2 Low SVOA	5.0
1,1-Biphenyl	92-52-4	nc	µg/L	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	SOM01.2 Low SVOA	5.0
Bis(2-chloroethoxy)methane	111-91-1	-	µg/L	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	SOM01.2 Low SVOA	5.0
Bis(2-chloroethyl)ether	111-44-4	c	µg/L	72,000	12,000	NS	NS	0.3	5.27	NS	NS	NS	NS	NS	0.3	SOM01.2 Low SVOA	5.0
Bis(2-chloroisopropyl) ether	108-60-1	c	µg/L	37,847	6,308	NS	NS	1,400	65,000	NS	NS	NS	NS	170,000	170,000	SOM01.2 Low SVOA	5.0
Bis(2-ethylhexyl) phthalate	117-81-7	c	µg/L	NS	300	NS	NS	6	41	NS	NS	NS	NS	NS	6	SOM01.2 Low SVOA	5.0
4-Bromophenyl phenyl ether	101-55-3	-	µg/L	NS	1.5	NS	NS	NS	NS	NS	NS	NS	NS	NS	1.5	SOM01.2 Low SVOA	5.0
Butyl benzyl phthalate	85-68-7	c	µg/L	560	93	883	147	1,500	1,900	NS	NS	NS	NS	5,200	5,200	SOM01.2 Low SVOA	5.0
Carbazole	86-74-8	c	µg/L	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	SOM01.2 Low SVOA	5.0
Caprolactum	105-60-2	nc	µg/L	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	SOM01.2 Low SVOA	5.0
4-Chloro-3-methylphenol	59-50-7	nc	µg/L	NS	0.3	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	SOM01.2 Low SVOA	5.0
4-Chloroaniline	106-47-8	c	µg/L	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	SOM01.2 Low SVOA	5.0
2-Chloronaphthalene	91-58-7	nc	µg/L	323	54	NS	NS	1,000	1,600	NS	NS	NS	NS	4,300	4,300	SOM01.2 Low SVOA	5.0
2-Chlorophenol	95-57-8	nc	µg/L	780	130	1,590	265	81	150	NS	NS	NS	NS	400	400	SOM01.2 Low SVOA	5.0
4-Chlorophenyl phenyl ether	7005-72-3	-	µg/L	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	SOM01.2 Low SVOA	5.0
Dibenzofuran	132-64-9	nc	µg/L	562	94	393	65	NS	NS	NS	NS	NS	NS	NS	65	SOM01.2 Low SVOA	5.0
3,3-Dichlorobenzidine	91-94-1	c	µg/L	315	53	219	37	0.32	0.44	NS	NS	NS	NS	NS	0.32	SOM01.2 Low SVOA	5.0
2,4-Dichlorophenol	120-83-2	nc	µg/L	510	85	NS	NS	77	290	NS	NS	NS	NS	NS	77	SOM01.2 Low SVOA	5.0
Diethyl phthalate	84-66-2	nc	µg/L	6,259	1,043	2,653	442	17,000	44,000	NS	NS	NS	NS	120,000	120,000	SOM01.2 Low SVOA	5.0
2,4-Dimethylphenol	105-67-9	nc	µg/L	630	105	NS	NS	257	571	NS	NS	NS	NS	2,300	2,300	SOM01.2 Low SVOA	5.0
4,6-Dinitro-2-methylphenol	534-52-1	-	µg/L	69	12	NS	NS	13	280	NS	NS	NS	NS	765	765	SOM01.2 Low SVOA	10
2,4-Dinitrophenol	51-28-5	nc	µg/L	186	31	3,990	670	69	5,300	NS	NS	NS	NS	14,000	14,000	SOM01.2 Low SVOA	10
2,4-Dinitrotoluene	121-14-2	nc	µg/L	7,290	1,220	NS	NS	1.1	34	NS	NS	NS	NS	NS	1.1	SOM01.2 Low SVOA	5.0
2,6-Dinitrotoluene	606-20-2	c	µg/L	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	SOM01.2 Low SVOA	5.0
Dimethyl phthalate	131-11-3	nc	µg/L	NS	330	NS	580	270,000	1,100,000	NS	NS	NS	NS	2,900,000	2,900,000	SOM01.2 Low SVOA	5.0
Di-n-butyl phthalate	84-74-2	nc	µg/L	221	7	150	5	1,318	3,010	NS	NS	NS	NS	12,000	12,000	SOM01.2 Low SVOA	5.0
Di-n-octyl phthalate	117-84-0	nc	µg/L	671	22	NS	NS	NS	NS	NS	NS	NS	NS	NS	22	SOM01.2 Low SVOA	5.0
Hexachlorobenzene	118-74-1	c	µg/L	NS	NS	NS	NS	0.0044	0.0045	NS	NS	NS	NS	NS	0.0044	SOM01.2 Low SVOA	5.0
Hexachlorobutadiene	87-68-3	c	µg/L	NS	0.93	NS	0.32	NS	NS	NS	NS	NS	NS	18	18	SOM01.2 Trace VOA	5.0
Hexachlorocyclopentadiene	77-47-4	nc	µg/L	2.1	0.07	NS	0.07	50	1,100	NS	NS	NS	NS	17,000	17,000	SOM01.2 Low SVOA	5.0
Hexachloroethane	67-72-1	c	µg/L	NS	12	NS	9.4	27	62	NS	NS	NS	NS	NS	9.4	SOM01.2 Low SVOA	5.0
Isophorone	78-59-1	c	µg/L	36,000	6,000	3,870	650	350	9,600	NS	NS	NS	NS	NS	350	SOM01.2 Low SVOA	5.0
2-Methylphenol	95-48-7	c	µg/L	3,360	560	3,060	510	NS	NS	NS	NS	NS	NS	NS	510	SOM01.2 Low SVOA	5.0
3- & 4-Methylphenols	15831-10-4	c	µg/L	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	SOM01.2 Low SVOA	5.0
2-Nitroaniline	88-74-4	nc	µg/L	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	SOM01.2 Low SVOA	10.0
3-Nitroaniline	99-09-2	-	µg/L	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	SOM01.2 Low SVOA	10.0
4-Nitroaniline	100-01-6	c	µg/L	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	SOM01.2 Low SVOA	10.0
Nitrobenzene	98-95-3	c	µg/L	NS	270	NS	66.8	11	463	NS	NS	NS	NS	1,900	1,900	SOM01.2 Low SVOA	5.0
2-Nitrophenol	88-75-5	-	µg/L	5,753	959	8,818	1,470	NS	NS	NS	NS	NS	NS	NS	959	SOM01.2 Low SVOA	5.0
4-Nitrophenol	100-02-7	-	µg/L	3,193	532	2,151	359	NS	NS	NS	NS	NS	NS	NS	359	SOM01.2 Low SVOA	10.0
N-Nitrosodi-n-propylamine	621-64-7	c	µg/L	600	20	3,600	120	0.05	5.1	NS	NS	NS	NS	NS	0.05	SOM01.2 Low SVOA	5.0
N-Nitrosodiphenylamine	86-30-6	c	µg/L	1,740	290	990,000	165,000	33	60	NS	NS	NS	NS	NS	33	SOM01.2 Low SVOA	5.0
Pentachlorophenol	87-86-5	c	µg/L	¹² 3.19	¹² 2.45	15.1	9.6	1	57	¹⁹ ⁶	¹⁵ ⁶	13	7.9	NS	7.9	SOM01.2 Low SVOA by SIM	0.2
Phenol	108-95-2	nc	µg/L	NS	110	16,500	2,750	10,000	860,000	NS	NS	NS	NS	4,600,000	4,600,000	SOM01.2 Low SVOA	5.0
1,2,4,5-Tetrachlorobenzene	95-94-3	nc	µg/L	NS	NS	NS	NS	0.65	0.71	NS	NS	NS	NS	NS	0.65	SOM01.2 Low SVOA	5.0
2,3,4,6-Tetrachlorophenol	58-90-2	nc	µg/L	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	SOM01.2 Low SVOA	5.0
2,4,5-Trichlorophenol	95-95-4	nc	µg/L	136	64	259	12	1,194	2,435	NS	NS	NS	NS	NS	12	SOM01.2 Low SVOA	5.0
2,4,6-Trichlorophenol	88-06-2	c	µg/L	81	13.5	363	61	14	24	NS	NS	NS	NS	NS	14	SOM01.2 Low SVOA	5.0
Polycyclic Aromatic Hydrocarbons																	
Acenaphthene	83-32-9	nc	µg/L	NS	23	NS	40.4	670	990	NS	NS	NS	NS	990	990	SOM01.2 Low SVOA	5.0
Acenaphthylene	208-96-8	nc	µg/L	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	SOM01.2 Low SVOA	5.0
Anthracene	120-12-7	nc	µg/L	1.8	0.3	1.08	0.18	5,569	40,000	NS	NS	NS	NS	40,000	40,000	SOM01.2 Low SVOA	5.0

TABLE A-2. REFERENCE LIMITS AND PROJECT ACTION LIMITS FOR SURFACE WATER,
FALCON REFINERY SUPERFUND SITE

Analyte	CASRN	c/hc	Units	TCEQ Surface Water Risk Based Exposure Limits (^{SW} RBEL) ¹						National Recommended Water Quality Criteria ²					Applicable Screening Criteria ³	Analytical Method*	CLP CRQL
				Aquatic Life Freshwater Acute	Aquatic Life Freshwater Chronic	Aquatic Life Saltwater Acute	Aquatic Life Saltwater Chronic	Human Health Water and Fish	Human Health Fish Only	Aquatic Life Freshwater Acute	Aquatic Life Freshwater Chronic	Aquatic Life Saltwater Acute	Aquatic Life Saltwater Chronic	Human Health for Consumption Organism Only			
Benzo(a)anthracene	56-55-3	c	µg/L	207.6	34.6	NS	NS	0.068	0.33	NS	NS	NS	NS	0.018	0.018	SOM01.2 Low SVOA by SIM	0.10
Benzo(b)fluoranthene	205-99-2	c	µg/L	NS	NS	NS	NS	0.038	0.18	NS	NS	NS	NS	0.018	0.018	SOM01.2 Low SVOA by SIM	0.10
Benzo(k)fluoranthene	207-08-9	c	µg/L	NS	NS	NS	NS	0.038	0.18	NS	NS	NS	NS	0.018	0.018	SOM01.2 Low SVOA by SIM	0.10
Benzo(g,h,i)perylene	191-24-2	nc	µg/L	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	SOM01.2 Low SVOA	5.0
Benzo(a)pyrene	50-32-8	c	µg/L	NS	0.014	NS	NS	0.068	0.33	NS	NS	NS	NS	0.018	0.018	SOM01.2 Low SVOA by SIM	0.10
Chrysene	218-01-9	c	µg/L	207	7	NS	NS	68.13	327	NS	NS	NS	NS	0.018	0.018	SOM01.2 Low SVOA by SIM	0.10
Dibenz(a,h)anthracene	53-70-3	c	µg/L	149	5	NS	NS	0.038	0.18	NS	NS	NS	NS	0.018	0.018	SOM01.2 Low SVOA by SIM	0.10
Fluoranthene	206-44-0	nc	µg/L	NS	6.16	NS	2.96	130	140	NS	NS	NS	NS	140	140	SOM01.2 Low SVOA	5.0
Fluorene	86-73-7	nc	µg/L	64	11	300	50	1,100	5,300	NS	NS	NS	NS	5,300	5,300	SOM01.2 Low SVOA	5.0
Indeno(1,2,3-cd)pyrene	193-39-5	c	µg/L	NS	NS	NS	NS	0.038	0.18	NS	NS	NS	NS	0.018	0.018	SOM01.2 Low SVOA by SIM	0.10
2-Methylnaphthalene	91-57-6	nc	µg/L	380	63	180	30	NS	NS	NS	NS	NS	NS	NS	30	SOM01.2 Low SVOA	5.0
Naphthalene	91-20-3	c	µg/L	1,480	250	750	125	NS	NS	NS	NS	NS	NS	NS	125	SOM01.2 Low SVOA	5.0
Phenanthrene	85-01-8	nc	µg/L	30	30	7.7	4.6	NS	NS	NS	NS	NS	NS	NS	4.6	SOM01.2 Low SVOA	5.0
Pyrene	129-00-0	nc	µg/L	206	7	7.4	0.24	830	4,000	NS	NS	NS	NS	4,000	4,000	SOM01.2 Low SVOA	5.0
Metals																	
Aluminum	7429-90-5	-	µg/L	991w (d)	⁹ 87	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	ISM01.3 ICP-MS	20.0
Antimony	7440-36-0	nc	µg/L	NS	160	NS	NS	6	1,071	NS	NS	NS	NS	NS	6	ISM01.3 ICP-MS	2.0
Arsenic	7440-38-2	c	µg/L	340w	150w	149w	78w	10	10	340	150	69	36	NS	36	ISM01.3 ICP-MS	1.0
Barium	7440-39-3	nc	µg/L	NS	16,000	NS	25,000	2,000	NS	NS	NS	NS	NS	NS	2,000	ISM01.3 ICP-MS	10.0
Beryllium	7440-41-7	c	µg/L	130	5.3	NS	NS	NS	NS	NS	NS	NS	NS	NS	5.3	ISM01.3 ICP-MS	1.0
Cadmium	7440-43-9	c	µg/L	⁸ 4.37	⁸ 0.15	40.0w	8.75w	5	NS	2.0 ⁴	0.25 ⁴	40	8.8	NS	8.8	ISM01.3 ICP-MS	1.0
Calcium	7440-70-2	-	µg/L	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	ISM01.3 ICP-MS	500
Chromium	7440-47-3	-	µg/L	NS	NS	NS	NS	NS	NS	16 ⁵	11 ⁵	1100 ⁵	50 ⁵	NS	11	ISM01.3 ICP-MS	2.0
Cobalt	7440-48-4	-	µg/L	45,000	1,500	NS	NS	NS	NS	NS	NS	NS	NS	NS	1,500	ISM01.3 ICP-MS	1.0
Copper	7440-50-8	nc	µg/L	⁸ 7.39	⁸ 5.24	⁷ 13.5w	3.6w	1,300	NS	13 ⁴	9.0 ⁴	4.8	3.1	NS	3.1	ISM01.3 ICP-MS	2.0
Iron	7439-89-6	-	µg/L	NS	1,000	NS	NS	300	NS	NS	1,000	NS	NS	NS	1,000	ISM01.3 ICP-MS	200
Lead	7439-92-1	c	µg/L	⁸ 30.14	⁸ 1.17	133w	5.3w	1.15	3.83	65 ⁴	2.5 ⁴	210	8.1	NS	8.1	ISM01.3 ICP-MS	1.0
Magnesium	7439-95-4	-	µg/L	19,410	3,235	NS	NS	NS	NS	NS	NS	NS	NS	NS	3,235	ISM01.3 ICP-MS	500
Manganese	7439-96-5	-	µg/L	NS	120	NS	NS	50	100	NS	NS	NS	NS	NS	50	ISM01.3 ICP-MS	1.0
Mercury	7439-97-6	nc	µg/L	2.4	1.3	2.1	1.1	0.021	0.021	1.4	0.77	1.8	0.94	NS	0.77	ISM01.3 CVAA	0.20
Nickel	7440-02-0	nc	µg/L	⁸ 260.5	⁸ 28.93	118w	13.1w	332	1,140	470 ⁴	52 ⁴	74	8.2	NS	8.2	ISM01.3 ICP-MS	1.0
Potassium	7440-09-7	-	µg/L	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	ISM01.3 ICP-MS	500
Selenium	7782-49-2	nc	µg/L	20	5	564	136	50	4200	NS	4.6	290	71	NS	4.6	ISM01.3 ICP-MS	5.0
Silver	7440-22-4	nc	µg/L	0.8w	¹⁴ 0.08w	2w	¹⁴ 0.2w	NS	NS	3.2 ⁴	NS	1.9	NS	NS	1.90	ISM01.3 ICP-MS	1.0
Sodium	7440-23-5	-	µg/L	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	ISM01.3 ICP-MS	500
Thallium	7440-28-0	nc	µg/L	NS	4	NS	21.3	0.75	1.5	NS	NS	NS	NS	NS	0.75	ISM01.3 ICP-MS	1.0
Vanadium	7440-62-2	nc	µg/L	NS	20	NS	NS	NS	NS	NS	NS	NS	NS	NS	20	ISM01.3 ICP-MS	5.0
Zinc	7440-66-6	nc	µg/L	⁸ 65.13	⁸ 65.66	92.7w	84.2w	7,400	26,000	120 ⁴	120 ⁴	90	81	NS	81	ISM01.3 ICP-MS	2.0

TABLE A-2. REFERENCE LIMITS AND PROJECT ACTION LIMITS FOR SURFACE WATER,
FALCON REFINERY SUPERFUND SITE

Analyte	CASRN	c/hc	Units	TCEQ Surface Water Risk Based Exposure Limits (^{SW} RBEL) ¹						National Recommended Water Quality Criteria ²					Applicable Screening Criteria ³	Analytical Method*	CLP CRQL
				Aquatic Life Freshwater Acute	Aquatic Life Freshwater Chronic	Aquatic Life Saltwater Acute	Aquatic Life Saltwater Chronic	Human Health Water and Fish	Human Health Fish Only	Aquatic Life Freshwater Acute	Aquatic Life Freshwater Chronic	Aquatic Life Saltwater Acute	Aquatic Life Saltwater Chronic	Human Health for Consumption Organism Only			
Notes: CRQLs in red cells are above the action level c - carcinogenic; nc - noncarcinogenic ⁸ Analytical methods were chosen based on the action level for the analyte in an attempt to ensure the CRQL is lower than the action level. ¹ TCEQ TRRP Human Health Surface Water RBELs Table and Aquatic Life Surface Water RBELs Table, updated January 2011 http://www.tceq.state.tx.us/remediation/trrp/trrppcls.html ² USEPA National Water Quality Criteria (accessed 18 June 2012 at http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm). ³ Applicable Screening Criteria refer to lowest EPA - National Recommended Water Quality Criteria. If it is not available then lowest TCEQ RBEL ⁴ Based on a dissolved metal, at a hardness of 100 mg/L as calcium carbonate. ⁵ Criteria for hexavalent chromium, based on a dissolved metal, at a hardness of 100 mg/L as calcium carbonate. ⁶ Based on a pH of 7.8. ⁷ In designated oyster waters, an acute saltwater copper criterion of 3.6 ug/L applies. ⁸ Value calculated using an assumed hardness of 50 mg/L as CaCO ₃ . The hardness-based formulas are on the next sheet. Persons should use the lower fifteenth percentile hardness value for the nearest downstream classified segment as listed in the agency’s Implementation Procedures, as amended. Alternatively, site-specific hardness values may be used. See discussion in Section 3.2.3 of of TRRP-24. ⁹ National Recommended Water Quality Criterion as provided in U.S. EPA, 2009. ¹⁰ Value derived by TCEQ using the LC ₅₀ approach. ¹¹ Chronic value is a surface water benchmark from the TCEQ Ecological Risk Assessment Guidance (RG-263 and updates). ¹² Value calculated using an assumed pH of 6. See formula on the next sheet and discussion in Section 3.2.3 of TRRP-24 for guidance on the appropriate pH value to use. ¹³ Acute value derived by the TCEQ Water Quality Division, 2003. In-house water quality chronic and acute values derived for wastewater permits and requests from the Office of Waste based on LC ₅₀ values in accordance with methodology defined in the TSWQS. ¹⁴ The indicated chronic value is an acute criterion (state or federal) divided by 10. (d) Indicates that the criteria for a specific parameter are for the dissolved portion in water. All other criteria are for total concentrations, except where noted.recoverable (w) Indicates that a criterion is multiplied by a water-effect ratio (WER) in order to incorporate the effects of local water chemistry or toxicity. The WER is equal to 1 except where sufficient data is available to establish a site-specific WER. The number preceding the w in the freshwater criterion equation is an EPA conversion factor. µg/L = microgram(s) per liter mg/L = milligram(s) per liter CASRN = Chemical Abstracts Service Registry Number CLP = Contract Laboratory Program CRQL = contract required quantitation limit CVAA = cold vapor atomic absorption EPA = U.S. Environmental Protection Agency ICP-MS = inductively copuled plasma-mass spectrometry LC ₅₀ = lethal concentration that kills 50% of test animals NS = not specified RBEL = Risk Based Exposure Limits SIM = selective ion monitoring SVOC = semivolatile organic compound TCEQ = Texas Commission on Environmental Quality TRRP = Texas Risk Reduction Program TSWQS = Texas Surface Water Quality Standards VOA = volatile organic compound																	

TABLE A-3. REFERENCE LIMITS AND PROJECT ACTION LIMITS FOR SURFACE AND SUBSURFACE SOIL,
FALCON REFINERY SUPERFUND SITE

Analyte	CASRN	Units	c/nc	TCEQ TRRP Residential Levels ¹			USEPA Regional Screening Levels ²					Applicable Screening Criteria ⁵	Analytical Method*	CLP CRQL	
				TotSoil Comb	GWSoil Ing	AirSoil Inh-V	Residential	Industrial	Protection of Ground Water	USEPA Eco-SSL Lowest Value ³	USEPA Eco-SSL Additional Values ⁴				
Volatile Organic Compounds															
Acetone	67-64-1	µg/kg	nc	66,000,000	43,000	650,000,000	61,000,000	630,000,000	2,400		NS		2,400	SOM01.2 Low Soil	10
Benzene	71-43-2	µg/kg	c	120,000	26	160,000	1,100	5,400	0.20		NS		0.20	SOM01.2 Low Soil	5.0
Bromochloromethane	74-97-5	µg/kg	nc				160,000	680,000	21		NS		21	SOM01.2 Low Soil	5.0
Bromodichloromethane	75-27-4	µg/kg	c	98,000	65	NS	270	1,400	0.032		NS		0.032	SOM01.2 Low Soil	5.0
Bromoform	75-25-2	µg/kg	c	400,000	630	840,000	62,000	220,000	2.1		NS		2.1	SOM01.2 Low Soil	5.0
Bromomethane (Methyl bromide)	74-83-9	µg/kg	nc	46,000	130	77,000	7,300	32,000	1.8		NS		1.8	SOM01.2 Low Soil	5.0
2-Butanone (Methyl ethyl ketone)	78-93-3	µg/kg	nc	40,000,000	29,000	200,000,000	28,000,000	200,000,000	1,000		NS		1,000	SOM01.2 Low Soil	10
Carbon disulfide	75-15-0	µg/kg	nc				820,000	3,700,000	210		NS		210	SOM01.2 Low Soil	5.0
Carbon tetrachloride	56-23-5	µg/kg	c				610	3,000	0.15		NS		0.15	SOM01.2 Low Soil	5.0
Chlorobenzene	108-90-7	µg/kg	nc				290,000	1,400,000	49		NS		49	SOM01.2 Low Soil	5.0
Chloroethane (Ethyl chloride)	75-00-3	µg/kg	nc				15,000,000	61,000,000	5,900		NS		5,900	SOM01.2 Low Soil	5.0
Chloroform	67-66-3	µg/kg	c				290	1,500	0.053		NS		0.053	SOM01.2 Low Soil	5.0
Chloromethane (Methyl chloride)	74-87-3	µg/kg	nc				120,000	500,000	49		NS		49	SOM01.2 Low Soil	5.0
Cyclohexane	110-82-7	µg/kg	nc				7,000,000	29,000,000	13,000		NS		13,000	SOM01.2 Low Soil	5.0
1,2-Dibromo-3-chloropropane (DBCP)	96-12-8	µg/kg	c				5.4	69	0.00014		NS		0.00014	SOM01.2 Low Soil	5.0
Dibromochloromethane (Chlorodibromomethane)	124-48-1	µg/kg	c				680	3,300	0.039		NS		0.039	SOM01.2 Low Soil	5.0
1,2-Dibromoethane (Ethylene dibromide [EDB])	106-93-4	µg/kg	c				34	170	0.0018		NS		0.0018	SOM01.2 Low Soil	5.0
1,2-Dichlorobenzene	95-50-1	µg/kg	nc	720,000			1,900,000	9,800,000	270		NS		270	SOM01.2 Low Soil	5.0
1,3-Dichlorobenzene	541-73-1	µg/kg	nc	120,000	6,700	120,000	NS	NS	NS		NS		6,700	SOM01.2 Low Soil	5.0
1,4-Dichlorobenzene	106-46-7	µg/kg	c	250,000			2,400	12,000	0.40		NS		0.40	SOM01.2 Low Soil	5.0
Dichlorodifluoromethane	75-71-8	µg/kg	nc				94,000	400,000	300		NS		300	SOM01.2 Low Soil	5.0
1,1-Dichloroethane	75-34-3	µg/kg	c				3,300	17,000	0.68		NS		0.68	SOM01.2 Low Soil	5.0
1,2-Dichloroethane	107-06-2	µg/kg	c				430	2,200	0.042		NS		0.042	SOM01.2 Low Soil	5.0
1,1-Dichloroethene	75-35-4	µg/kg	c				240,000	1,100,000	93		NS		93	SOM01.2 Low Soil	5.0
1,2-Dichloroethene (cis)	156-59-2	µg/kg	nc				160,000	2,000,000	8.2		NS		8.2	SOM01.2 Low Soil	5.0
1,2-Dichloroethene (trans)	156-60-5	µg/kg	nc				150,000	690,000	25		NS		25	SOM01.2 Low Soil	5.0
1,2-Dichloropropane	78-87-5	µg/kg	c	61,000			940	4,700	0.13		NS		0.13	SOM01.2 Low Soil	5.0
1,3-Dichloropropene (cis)	10061-01-5	µg/kg	-	8,000	7	310,000	NS	NS	NS		NS		7	SOM01.2 Low Soil	5.0
1,3-Dichloropropene (trans)	10061-02-6	µg/kg	-	36,000	36	90,000	NS	NS	NS		NS		36	SOM01.2 Low Soil	5.0
1,4-Dioxane	123-91-1	µg/kg	c				4,900	17,000	0.14		NS		0.14	SOM01.2 Low Soil	100
Ethylbenzene	100-41-4	µg/kg	c				5,400	27,000	1.5		NS		1.5	SOM01.2 Low Soil	5.0
2-Hexanone	591-78-6	µg/kg	nc				210,000	1,400,000	7.9		NS		7.9	SOM01.2 Low Soil	10
Isopropylbenzene (Cumene)	98-82-8	µg/kg	nc				2,100,000	11,000,000	640		NS		640	SOM01.2 Low Soil	5.0
4-Methyl-2-pentanone (Methyl isobutyl ketone)	108-10-1	µg/kg	nc				5,300,000	53,000,000	230		NS		230	SOM01.2 Low Soil	10
Methyl acetate	79-20-9	µg/kg	nc				78,000,000	1,000,000,000	3,200		NS		3,200	SOM01.2 Low Soil	5.0
Methylcyclohexane	108-87-2	µg/kg	nc	41,396,696	15,553,090	46,052,891	NS	NS	NS		NS		15,553,090	SOM01.2 Low Soil	5.0
Methylene chloride	75-09-2	µg/kg	c				56,000	960,000	2.5		NS		2.5	SOM01.2 Low Soil	5.0
Methyl-tertiary-butyl ether	1634-04-4	µg/kg	c				43,000	220,000	2.8		NS		2.8	SOM01.2 Low Soil	5.0
Styrene	100-42-5	µg/kg	nc				6,300,000	36,000,000	1,200		NS		1,200	SOM01.2 Low Soil	5.0
1,1,2,2-Tetrachloroethane	79-34-5	µg/kg	c				560	2,800	0.026		NS		0.026	SOM01.2 Low Soil	5.0
Tetrachloroethene (PCE)	127-18-4	µg/kg	c				22,000	110,000	4.4		NS		4.4	SOM01.2 Low Soil	5.0
Toluene	108-88-3	µg/kg	nc				5,000,000	45,000,000	590		NS		590	SOM01.2 Low Soil	5.0
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	µg/kg	nc				43,000,000	180,000,000	130,000		NS		130,000	SOM01.2 Low Soil	5.0
1,2,3-Trichlorobenzene	86-61-6	µg/kg	-				49,000	490,000	15		NS		15	SOM01.2 Low Soil	5.0
1,2,4-Trichlorobenzene	120-82-1	µg/kg	nc				22,000	99,000	2.9		NS		2.9	SOM01.2 Low Soil	5.0
1,1,1-Trichloroethane	71-55-6	µg/kg	nc				8,700,000	38,000,000	2,600		NS		2,600	SOM01.2 Low Soil	5.0
1,1,2-Trichloroethane	79-00-5	µg/kg	c				1,100	5,300	0.077		NS		0.077	SOM01.2 Low Soil	5.0
Trichloroethene (TCE)	79-01-6	µg/kg	nc				910	6,400	0.16		NS		0.16	SOM01.2 Low Soil	5.0
Trichlorofluoromethane	75-69-4	µg/kg	nc				790,000	3,400,000	690		NS		690	SOM01.2 Low Soil	5.0
Vinyl chloride	75-01-4	µg/kg	c				60	1,700	0.0053		NS		0.0053	SOM01.2 Low Soil	5.0
m- & p-Xylenes	179601-23-1	µg/kg	-				590,000	2,500,000	180		NS		180	SOM01.2 Low Soil	5.0
o-Xylene	95-47-6	µg/kg	-				690,000	3,000,000	190		NS		190	SOM01.2 Low Soil	5.0
Semivolatile Organic Compounds															
Acetophenone	98-86-2	µg/kg	nc				7,800,000	100,000,000	450		NS		450	SOM01.2 Low Soil	170
Atrazine	1912-24-9	µg/kg	c				2,100	7,500	260		NS		260	SOM01.2 Low Soil	170
Benzaldehyde	100-52-7	µg/kg	nc				7,800,000	100,000,000	330		NS		330	SOM01.2 Low Soil	170
1,1-Biphenyl	92-52-4	µg/kg	nc				51,000	210,000	8.7		NS		8.7	SOM01.2 Low Soil	170
Bis(2-chloroethoxy)methane	111-91-1	µg/kg	-				180,000	1,800,000	11		NS		11	SOM01.2 Low Soil	170
Bis(2-chloroethyl)ether	111-44-4	µg/kg	c				210	1,000	0.0031		NS		0.0031	SOM01.2 Low Soil	170
Bis(2-chloroisopropyl) ether	108-60-1	µg/kg	c				4,600	22,000	0.11		NS		0.11	SOM01.2 Low Soil	170
Bis(2-ethylhexyl) phthalate	117-81-7	µg/kg	c				35,000	120,000	17		NS		17	SOM01.2 Low Soil	170
4-Bromophenyl phenyl ether	101-55-3	µg/kg	-	280	350	9,800	NS	NS	NS		NS		280	SOM01.2 Low Soil	170
Butyl benzyl phthalate	85-68-7	µg/kg	c				260,000	910,000	200		NS		200	SOM01.2 Low Soil	170
Carbazole	86-74-8	µg/kg	c	230,000	4,600	NS	NS	NS	NS		NS		4,600	SOM01.2 Low Soil	170
Caprolactum	105-60-2	µg/kg	nc				31,000,000	310,000,000	1,900		NS		1,900	SOM01.2 Low Soil	170

TABLE A-3. REFERENCE LIMITS AND PROJECT ACTION LIMITS FOR SURFACE AND SUBSURFACE SOIL,
FALCON REFINERY SUPERFUND SITE

Analyte	CASRN	Units	c/hc	TCEQ TRRP Residential Levels ¹			USEPA Regional Screening Levels ²					Applicable Screening Criteria ⁵	Analytical Method*	CLP CRQL
				Tot ^l Soil Comb	GW ^c Soil Ing	Air ^l Soil Inh-V	Residential	Industrial	Protection of Ground Water	USEPA Eco-SSL Lowest Value ³	USEPA Eco-SSL Additional Values ⁴			
4-Chloro-3-methylphenol (p-chloro-m-Cresol)	59-50-7	µg/kg	nc				6,100,000	62,000,000	1,300	NS	NS	1,300	SOM01.2 Low Soil	170
4-Chloroaniline	106-47-8	µg/kg	c				2,400	8,600	0.13	NS	NS	0.13	SOM01.2 Low Soil	170
2-Chloronaphthalene	91-58-7	µg/kg	nc				6,300,000	82,000,000	2,900	NS	NS	2,900	SOM01.2 Low Soil	170
2-Chlorophenol	95-57-8	µg/kg	nc				390,000	5,100,000	57	NS	NS	57	SOM01.2 Low Soil	170
4-Chlorophenyl phenyl ether	7005-72-3	µg/kg	-	160	32	2,500	NS	NS	NS	NS	NS	32	SOM01.2 Low Soil	170
Dibenzofuran	132-64-9	µg/kg	nc				78,000	1,000,000	110	NS	NS	110	SOM01.2 Low Soil	170
3,3-Dichlorobenzidine	91-94-1	µg/kg	c				1,100	3,800	0.71	NS	NS	0.71	SOM01.2 Low Soil	170
2,4-Dichlorophenol	120-83-2	µg/kg	nc				180,000	1,800,000	41	NS	NS	41	SOM01.2 Low Soil	170
Diethyl phthalate	84-66-2	µg/kg	nc				49,000,000	490,000,000	4,700	NS	NS	4,700	SOM01.2 Low Soil	170
2,4-Dimethylphenol	105-67-9	µg/kg	nc				1,200,000	12,000,000	320	NS	NS	320	SOM01.2 Low Soil	170
4,6-Dinitro-2-methylphenol (4,6-Dinitro-o-cresol)	534-52-1	µg/kg	-				4,900	49,000	2.0	NS	NS	2.0	SOM01.2 Low Soil	330
2,4-Dinitrophenol	51-28-5	µg/kg	nc				120,000	1,200,000	34	NS	NS	34	SOM01.2 Low Soil	330
2,4-Dinitrotoluene	121-14-2	µg/kg	nc				1,600	5,500	0.28	NS	NS	0.28	SOM01.2 Low Soil	170
2,6-Dinitrotoluene	606-20-2	µg/kg	c				61,000	620,000	20	NS	NS	20	SOM01.2 Low Soil	170
Dimethyl phthalate	131-11-3	µg/kg	nc	53,000,000	62,000	NS	NS	NS	NS	NS	NS	62,000	SOM01.2 Low Soil	170
Di-n-butyl phthalate	84-74-2	µg/kg	nc	6,200,000	3,300,000	NS	6,100,000	62,000,000	1,700	NS	NS	1,700	SOM01.2 Low Soil	170
Di-n-octyl phthalate	117-84-0	µg/kg	nc	2,600,000	1,000,000,000	NS	730,000	7,400,000	53,000	NS	NS	53,000	SOM01.2 Low Soil	170
Hexachlorobenzene	118-74-1	µg/kg	c				300	1,100	0.53	NS	NS	0.53	SOM01.2 Low Soil	170
Hexachlorobutadiene	87-68-3	µg/kg	c				6,200	22,000	0.5	NS	NS	0.5	SOM01.2 Low Soil	170
Hexachlorocyclopentadiene	77-47-4	µg/kg	nc				370,000	3,700,000	70	NS	NS	70	SOM01.2 Low Soil	170
Hexachloroethane	67-72-1	µg/kg	c				12,000	43,000	0.48	NS	NS	0.48	SOM01.2 Low Soil	170
Isophorone	78-59-1	µg/kg	c				510,000	1,800,000	22	NS	NS	22	SOM01.2 Low Soil	170
2-Methylphenol	95-48-7	µg/kg	c				3,100,000	31,000,000	580	NS	NS	580	SOM01.2 Low Soil	170
3- & 4-Methylphenols	15831-10-4	µg/kg	c				3,100,000	31,000,000	570	NS	NS	570	SOM01.2 Low Soil	170
2-Nitroaniline	88-74-4	µg/kg	nc	14,000			610,000	6,000,000	62	NS	NS	62	SOM01.2 Low Soil	330
3-Nitroaniline	99-09-2	µg/kg	-	15,000	26	60,000	NS	NS	NS	NS	NS	26	SOM01.2 Low Soil	330
4-Nitroaniline	100-01-6	µg/kg	c	220,000			24,000	86,000	1.4	NS	NS	1.4	SOM01.2 Low Soil	330
Nitrobenzene	98-95-3	µg/kg	c	66,000			4,800	24,000	0.079	NS	NS	0.079	SOM01.2 Low Soil	170
2-Nitrophenol	88-75-5	µg/kg	-	130,000	130	NS	NS	NS	NS	NS	NS	130	SOM01.2 Low Soil	170
4-Nitrophenol	100-02-7	µg/kg	-	130,000	100	NS	NS	NS	NS	NS	NS	100	SOM01.2 Low Soil	330
N-Nitrosodi-n-propylamine	621-64-7	µg/kg	c	400			69	250	0.0070	NS	NS	0.0070	SOM01.2 Low Soil	170
N-Nitrosodiphenylamine	86-30-6	µg/kg	c	570,000			99,000	350,000	57	NS	NS	57	SOM01.2 Low Soil	170
Pentachlorophenol	87-86-5	µg/kg	c				890	2,700	1.7	2.1	Based on avian receptors (2.8 for mammalian)	1.7	SOM01.2 Low Soil by SIM	6.7
Phenol	108-95-2	µg/kg	nc				18,000,000	180,000,000	2,600	NS	NS	2,600	SOM01.2 Low Soil	170
1,2,4,5-Tetrachlorobenzene	95-94-3	µg/kg	nc				18,000	180,000	5.8	NS	NS	5.8	SOM01.2 Low Soil	170
2,3,4,6-Tetrachlorophenol	58-90-2	µg/kg	nc				1,800	18,000	1,100	NS	NS	1,100	SOM01.2 Low Soil	170
2,4,5-Trichlorophenol	95-95-4	µg/kg	nc				6,100,000	62,000,000	3,300	NS	NS	3,300	SOM01.2 Low Soil	170
2,4,6-Trichlorophenol	88-06-2	µg/kg	c				44,000	160,000	13	NS	NS	13	SOM01.2 Low Soil	170
Tributyltin Compounds	NA	µg/kg	nc				18,000	180,000	230,000	NS	NS	18,000	TBD	TBD
Polycyclic Aromatic Hydrocarbons														
Acenaphthene	83-32-9	µg/kg	nc	3,000,000			3,400,000	33,000,000	4,100	1,100	HMW-PAH based on mammalian receptors (18,000 for soil invertebrates)	1,100	SOM01.2 Low Soil	170
Acenaphthylene	208-96-8	µg/kg	nc	3,800,000	410,000	NS	NS	NS	NS	1,100	HMW-PAH based on mammalian receptors (18,000 for soil invertebrates)	1,100	SOM01.2 Low Soil	170
Anthracene	120-12-7	µg/kg	nc	18,000,000			17,000,000	170,000,000	42,000	29,000	LMW-PAH based on soil invertebrates (100,000 for mammalian)	29,000	SOM01.2 Low Soil	170
Benzo(a)anthracene	56-55-3	µg/kg	c	5,700			150	2,100	10	1,100	HMW-PAH based on mammalian receptors (18,000 for soil invertebrates)	10	SOM01.2 Low Soil by SIM	3.3
Benzo(b)fluoranthene	205-99-2	µg/kg	c	5,700			150	2,100	35	1,100	HMW-PAH based on mammalian receptors (18,000 for soil invertebrates)	35	SOM01.2 Low Soil by SIM	3.3
Benzo(k)fluoranthene	207-08-9	µg/kg	c	5,700			1,500	21,000	350	1,100	HMW-PAH based on mammalian receptors (18,000 for soil invertebrates)	350	SOM01.2 Low Soil	170
Benzo(g,h,i)perylene	191-24-2	µg/kg	nc	1,800,000	46,000,000	NS	NS	NS	NS	1,100	HMW-PAH based on mammalian receptors (18,000 for soil invertebrates)	1,100	SOM01.2 Low Soil	170

TABLE A-3. REFERENCE LIMITS AND PROJECT ACTION LIMITS FOR SURFACE AND SUBSURFACE SOIL,
FALCON REFINERY SUPERFUND SITE

Analyte	CASRN	Units	c/hc	TCEQ TRRP Residential Levels ¹			USEPA Regional Screening Levels ²					Applicable Screening Criteria ⁵	Analytical Method*	CLP CRQL
				Tot ^{Soil} Comb	GW ^{Soil} Ing	Air ^{Soil} Inh-V	Residential	Industrial	Protection of Ground Water	USEPA Eco-SSL Lowest Value ³	USEPA Eco-SSL Additional Values ⁴			
Benzo(a)pyrene	50-32-8	µg/kg	c	560			15	210	3.5	1,100	HMW-PAH based on mammalian receptors (18,000 for soil invertebrates)	3.5	SOM01.2 Low Soil by SIM	3.3
Chrysene	218-01-9	µg/kg	c	560,000			15,000	210,000	1,100	1,100	HMW-PAH based on mammalian receptors (18,000 for soil invertebrates)	1,100	SOM01.2 Low Soil	170
Dibenz(a,h)anthracene	53-70-3	µg/kg	c	550			15	210	11	1,100	HMW-PAH based on mammalian receptors (18,000 for soil invertebrates)	11	SOM01.2 Low Soil by SIM	3.3
Fluoranthene	206-44-0	µg/kg	nc	2,300,000			2,300,000	22,000,000	70,000	29,000	LMW-PAH based on soil invertebrates (100,000 for mammalian)	29,000	SOM01.2 Low Soil	170
Fluorene	86-73-7	µg/kg	nc	2,300,000			2,300,000	22,000,000	4,000	29,000	LMW-PAH based on soil invertebrates (100,000 for mammalian)	4,000	SOM01.2 Low Soil	170
Indeno(1,2,3-cd)pyrene	193-39-5	µg/kg	c	5,700			150	2,100	120	29,000	HMW-PAH based on mammalian receptors (18,000 for soil invertebrates)	120	SOM01.2 Low Soil by SIM	3.3
2-Methylnaphthalene	91-57-6	µg/kg	nc	250,000			230,000	2,200,000	140	29,000	LMW-PAH based on soil invertebrates (100,000 for mammalian)	140	SOM01.2 Low Soil by SIM	3.3
Naphthalene	91-20-3	µg/kg	c	220,000			3,600	18,000	0.47	29,000	LMW-PAH based on soil invertebrates (100,000 for mammalian)	0.47	SOM01.2 Low Soil by SIM	3.3
Phenanthrene	85-01-8	µg/kg	nc	1,700,000	420,000	NS	NS	NS	NS	29,000	LMW-PAH based on soil invertebrates (100,000 for mammalian)	29,000	SOM01.2 Low Soil	170
Pyrene	129-00-0	µg/kg	nc	1,700,000			1,700,000	17,000,000	9,500	1,100	HMW-PAH based on mammalian receptors (18,000 for soil invertebrates)	1,100	SOM01.2 Low Soil	170
Total Metals														
Aluminum	7429-90-5	mg/kg	nc	65,000			77,000	990,000	23,000	NS	Not enough information to provide an Eco-SSL, instead if pH<5.5 then aluminum may be of concern	23,000	ISM01.3 ICP-AES	20
Antimony	7440-36-0	mg/kg	nc	15			31	410	0.27	0.27	Based on mammalian (78 for soil invertebrates)	0.27	ISM01.3 ICP-AES	6
Arsenic	7440-38-2	mg/kg	c	24			0.39	1.6	0.0013	18	Based on terrestrial plants (43 for avian, 46 for mammalian)	0.0013	ISM01.3 ICP-AES	1
Barium	7440-39-3	mg/kg	nc	8,100			15,000	190,000	120	330	Based on soil invertebrates (2,000 for mammalian)	120	ISM01.3 ICP-AES	20
Beryllium	7440-41-7	mg/kg	c	38			160	2,000	13	21	Based on mammalian (40 for soil invertebrates)	13	ISM01.3 ICP-AES	0.5
Cadmium	7440-43-9	mg/kg	c	52			70	800	0.52	0.36	Based on mammalian (0.77 for avian receptors, 32 for plants, 140 for soil invertebrates)	0.36	ISM01.3 ICP-AES	0.5
Calcium	7440-70-2	mg/kg	-	1,000,000	1,000,000	1,000,000	NS	NS	NS	NS	NS	1,000,000	ISM01.3 ICP-AES	500
Chromium	7440-47-3	mg/kg	nc	Cr III = 33,000 Cr VI = 120 Cr Total =33,000			Cr VI = 0.29	Cr VI = 5.6	Cr VI = 0.00059	Cr III = 26 CrVI = 130	CrIII based on avian (34 for mammalian) and CrVI based on mammalian	0.00059	ISM01.3 ICP-AES	1
Cobalt	7440-48-4	mg/kg	nc	21			23	300	0.21	13	Based on terrestrial plants (120 for avian and 230 for mammalian)	0.21	ISM01.3 ICP-AES	5
Copper	7440-50-8	mg/kg	nc	550			3,100	41,000	22	28	Based on avian receptors (49 for mammalian, 70 for plants, and 80 for soil invertebrates)	22	ISM01.3 ICP-AES	2.5
Iron	7439-89-6	mg/kg	nc	1,000,000			55,000	720,000	270	NE	A determination of the geochemical conditions (i.e., pH and Eh at a minimum) of the environmental setting, as well as the presence of iron floc and the toxic metals, is critical to the determination of the relative importance of iron at a site.	270	ISM01.3 ICP-AES	10

TABLE A-3. REFERENCE LIMITS AND PROJECT ACTION LIMITS FOR SURFACE AND SUBSURFACE SOIL,
FALCON REFINERY SUPERFUND SITE

Analyte	CASRN	Units	c/hc	TCEQ TRRP Residential Levels ¹			USEPA Regional Screening Levels ²					Applicable Screening Criteria ⁵	Analytical Method*	CLP CRQL
				TotSoil Comb	GWSoil Ing	AirSoil Inh-V	Residential	Industrial	Protection of Ground Water	USEPA Eco-SSL Lowest Value ³	USEPA Eco-SSL Additional Values ⁴			
Lead	7439-92-1	mg/kg	-	500			400	800	NS	11	Based on avian receptors (56 for mammalian, 120 for plants, and 1,700 for soil invertebrates)	11	ISM01.3 ICP-AES	1
Magnesium	7439-95-4	mg/kg	-	1,000,000	1,000,000	1,000,000	NS	NS	NS	NS	NS	1,000,000	ISM01.3 ICP-AES	500
Manganese	7439-96-5	mg/kg	nc	3,700			1,800	23,000	21	220	Based on terrestrial plants (450 for soil invertebrates, 4,000 for mammalian, and 4,300 for avian)	21	ISM01.3 ICP-AES	1.5
Mercury	7439-97-6	mg/kg	nc	3.6			10	43	0.033	0.1	This value is from Table 3 of "Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 Revision"	0.033	ISM01.3 CVAA	0.1
Nickel	7440-02-0	mg/kg	nc	840			1,500	20,000	20	38	Based on terrestrial plants (130 for mammalian, 210 for avian, and 280 for soil invertebrates)	20	ISM01.3 ICP-AES	4
Potassium	7440-09-7	mg/kg	-	1,000,000	1,000,000	1,000,000	NS	NS	NS	NS	NS	1,000,000	ISM01.3 ICP-AES	500
Selenium	7782-49-2	mg/kg	nc	310			390	5,100	0.40	0.52	Based on terrestrial plants (0.63 for mammalian, 1.2 for avian, and 4.1 for soil invertebrates)	0.40	ISM01.3 ICP-AES	3.5
Silver	7440-22-4	mg/kg	nc	97			390	5,100	0.60	4.2	Based on avian receptors (14 for mammalian and 560 for plants)	0.60	ISM01.3 ICP-AES	1
Sodium	7440-23-5	mg/kg	-	1,000,000	1,000,000	1,000,000	NS	NS	NS	NS	NS	1,000,000	ISM01.3 ICP-AES	500
Thallium	7440-28-0	mg/kg	nc	6.3			0.78	10	0.011	NS	NS	0.011	ISM01.3 ICP-AES	2.5
Vanadium	7440-62-2	mg/kg	nc	76			390	5,200	78	7.8	Based on avian receptors (280 for mammalian)	7.8	ISM01.3 ICP-AES	5
Zinc	7440-66-6	mg/kg	nc	9,900			23,000	310,000	290	46	Based on avian receptors (79 for mammalian, 120 for soil invertebrates, and 160 for plants)	46	ISM01.3 ICP-AES	6
Notes: * Analytical methods were chosen based on the action level for the analyte in an attempt to ensure the CRQL is lower than the action level. c - carcinogenic; nc - noncarcinogenic CRQLs in red cells are above the action level ¹ TCEQ TRRP Table 1 Tier 1 Residential Soil PCLs, June 29, 2012 ² USEPA November 2012 RSLs as presented at the following website at http://www.epa.gov/region9/superfund/prg/ . ³ USEPA 2012b. Ecological Soil Screening Levels. http://www.epa.gov/ecotox/ecossl/ . Accessed on 19 June 2012. Ecological screening levels for soil are only applicable to surface or shallow subsurface soil. ⁴ The lowest ecological risk soil screening value from the Risk Assessment Information System (RAIS) database, found at http://rais.ornl.gov/tools/eco_search.php and accessed July 2012. ⁵ Applicable Screening Criteria refer to the lowest applicable USEPA RSL screening level. If no RSL exists, then lowest applicable TCEQ TRRP Residential Level. µg/kg = microgram(s) per kilogram CASRN = Chemical Abstracts Service Registry Number CLP = Contract Laboratory Program Cr = chromium CRQL = Contract Required Quantitation Limit CVAA = cold vapor atomic absorption DL = detection limit Eco-SSL = Ecological Soil Screening Levels HMW-PAH = high molecular weight polycyclic aromatic hydrocarbons ICP-AES = inductively coupled plasma-atomic emission spectroscopy LMW-PAH - low molecular weight polycyclic aromatic hydrocarbons mg/kg = milligram(s) per kilogram NA = not applicable NE = contaminant listed in guidance but not enough information to establish a screening limit NS = not specified PAL = project action limit PCL = protective concentration level RRO = residual range organics RSL = Regional Screening Level SIM = selected ion monitoring TBD = to be determined TCEQ = Texas Commission on Environmental Quality TRRP = Texas Risk Reduction Program USEPA = U.S. Environmental Protection Agency														

TABLE A-4. REFERENCE LIMITS AND PROJECT ACTION LIMITS FOR SEDIMENT
FALCON REFINERY SUPERFUND SITE

Analyte	CASRN	Units	c/nc	TCEQ TRRP Residential ¹ TotSoil Comb	USEPA Regional Screening Level ²	Protection of Benthic Invertebrates Screening Level ³	Applicable Screening Criteria ⁴	Analytical Method*	CLP CRQL
Volatile Organic Compounds									
Acetone	67-64-1	µg/kg	nc	66,000,000	61,000,000	NS	61,000,000	SOM01.2 Low Soil	10
Benzene	71-43-2	µg/kg	c	120,000	1,100	10	10	SOM01.2 Low Soil	5.0
Bromochloromethane	74-97-5	µg/kg	nc		160,000	NS	160,000	SOM01.2 Low Soil	5.0
Bromodichloromethane	75-27-4	µg/kg	c	98,000	270	NS	270	SOM01.2 Low Soil	5.0
Bromoform	75-25-2	µg/kg	c	400,000	62,000	NS	62,000	SOM01.2 Low Soil	5.0
Bromomethane (Methyl bromide)	74-83-9	µg/kg	nc	46,000	7,300	NS	7,300	SOM01.2 Low Soil	5.0
2-Butanone (Methyl ethyl ketone)	78-93-3	µg/kg	nc	40,000,000	28,000,000	NS	28,000,000	SOM01.2 Low Soil	10
Carbon disulfide	75-15-0	µg/kg	nc		820,000	NS	820,000	SOM01.2 Low Soil	5.0
Carbon tetrachloride	56-23-5	µg/kg	c		610	170	170	SOM01.2 Low Soil	5.0
Chlorobenzene	108-90-7	µg/kg	nc		290,000	30	30	SOM01.2 Low Soil	5.0
Chloroethane (Ethyl chloride)	75-00-3	µg/kg	nc		15,000,000	NS	15,000,000	SOM01.2 Low Soil	5.0
Chloroform	67-66-3	µg/kg	c		290	20	20	SOM01.2 Low Soil	5.0
Chloromethane (Methyl chloride)	74-87-3	µg/kg	nc		120,000	NS	120,000	SOM01.2 Low Soil	5.0
Cyclohexane	110-82-7	µg/kg	nc		7,000,000	NS	7,000,000	SOM01.2 Low Soil	5.0
1,2-Dibromo-3-chloropropane (DBCP)	96-12-8	µg/kg	c		5.4	NS	5.4	SOM01.2 Low Soil	5.0
Dibromochloromethane (Chlorodibromomethane)	124-48-1	µg/kg	c		680	NS	680	SOM01.2 Low Soil	5.0
1,2-Dibromoethane (Ethylene dibromide [EDB])	106-93-4	µg/kg	c		34	NS	34	SOM01.2 Low Soil	5.0
1,2-Dichlorobenzene	95-50-1	µg/kg	nc	720,000	1,900,000	30	30	SOM01.2 Low Soil	5.0
1,3-Dichlorobenzene	541-73-1	µg/kg	nc	120,000	NS	30	30	SOM01.2 Low Soil	5.0
1,4-Dichlorobenzene	106-46-7	µg/kg	c	250,000	2,400	30	30	SOM01.2 Low Soil	5.0
Dichlorodifluoromethane	75-71-8	µg/kg	nc		94,000	NS	94,000	SOM01.2 Low Soil	5.0
1,1-Dichloroethane	75-34-3	µg/kg	c		3,300	20	20	SOM01.2 Low Soil	5.0
1,2-Dichloroethane	107-06-2	µg/kg	c		430	20	20	SOM01.2 Low Soil	5.0
1,1-Dichloroethene	75-35-4	µg/kg	c		240,000	100	100	SOM01.2 Low Soil	5.0
1,2-Dichloroethene (cis)	156-59-2	µg/kg	nc		160,000	200	200	SOM01.2 Low Soil	5.0
1,2-Dichloroethene (trans)	156-60-5	µg/kg	nc		150,000	200	200	SOM01.2 Low Soil	5.0
1,2-Dichloropropane	78-87-5	µg/kg	c	61,000	940	2.0	2.0	SOM01.2 Low Soil	5.0
1,3-Dichloropropene (cis)	10061-01-5	µg/kg	-	8,000	NS	NS	8,000	SOM01.2 Low Soil	5.0
1,3-Dichloropropene (trans)	10061-02-6	µg/kg	-	36,000	NS	NS	36,000	SOM01.2 Low Soil	5.0
1,4-Dioxane	123-91-1	µg/kg	c	NS	4,900	NS	4,900	SOM01.2 Low Soil	100
Ethylbenzene	100-41-4	µg/kg	c		5,400	30	30	SOM01.2 Low Soil	5.0
2-Hexanone	591-78-6	µg/kg	nc		210,000	NS	210,000	SOM01.2 Low Soil	10
Isopropylbenzene (Cumene)	98-82-8	µg/kg	nc		2,100,000	NS	2,100,000	SOM01.2 Low Soil	5.0
4-Methyl-2-pentanone (Methyl isobutyl ketone)	108-10-1	µg/kg	nc		5,300,000	NS	5,300,000	SOM01.2 Low Soil	10
Methyl acetate	79-20-9	µg/kg	nc		78,000,000	NS	78,000,000	SOM01.2 Low Soil	5.0
Methylcyclohexane	108-87-2	µg/kg	nc	41,396,696	NS	NS	41,396,696	SOM01.2 Low Soil	5.0
Methylene chloride	75-09-2	µg/kg	c		56,000	18	18	SOM01.2 Low Soil	5.0
Methyl-tertiary-butyl ether	1634-04-4	µg/kg	c		43,000	NS	43,000	SOM01.2 Low Soil	5.0
Styrene	100-42-5	µg/kg	nc		6,300,000	200	200	SOM01.2 Low Soil	5.0
1,1,2,2-Tetrachloroethane	79-34-5	µg/kg	c		560	NS	560	SOM01.2 Low Soil	5.0
Tetrachloroethene (PCE)	127-18-4	µg/kg	c		22,000	2.0	2.0	SOM01.2 Low Soil	5.0
Toluene	108-88-3	µg/kg	nc		5,000,000	NS	5,000,000	SOM01.2 Low Soil	5.0
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	µg/kg	nc		43,000,000	NS	43,000,000	SOM01.2 Low Soil	5.0
1,2,3-Trichlorobenzene	86-61-6	µg/kg	-		49,000	11	11	SOM01.2 Low Soil	5.0

TABLE A-4. REFERENCE LIMITS AND PROJECT ACTION LIMITS FOR SEDIMENT
FALCON REFINERY SUPERFUND SITE

Analyte	CASRN	Units	c/nc	TCEQ TRRP Residential ¹ Tot ¹ Soil Comb	USEPA Regional Screening Level ²	Protection of Benthic Invertebrates Screening Level ³	Applicable Screening Criteria ⁴	Analytical Method*	CLP CRQL
1,2,4-Trichlorobenzene	120-82-1	µg/kg	nc		22,000	11	11	SOM01.2 Low Soil	5.0
1,1,1-Trichloroethane	71-55-6	µg/kg	nc		8,700,000	70	70	SOM01.2 Low Soil	5.0
1,1,2-Trichloroethane	79-00-5	µg/kg	c		1,100	400	400	SOM01.2 Low Soil	5.0
Trichloroethene (TCE)	79-01-6	µg/kg	nc		910	7.8	7.8	SOM01.2 Low Soil	5.0
Trichlorofluoromethane	75-69-4	µg/kg	nc		790,000	NS	790,000	SOM01.2 Low Soil	5.0
Vinyl chloride	75-01-4	µg/kg	c		60	10	10	SOM01.2 Low Soil	5.0
m- & p-Xylenes	179601-23-1	µg/kg	-		590,000	110	110	SOM01.2 Low Soil	5.0
o-Xylene	95-47-6	µg/kg	-		690,000	89	89	SOM01.2 Low Soil	5.0
Semivolatile Organic Compounds									
Acetophenone	98-86-2	µg/kg	nc		7,800,000	NS	7,800,000	SOM01.2 Low Soil	170
Atrazine	1912-24-9	µg/kg	c		2,100	NS	2,100	SOM01.2 Low Soil	170
Benzaldehyde	100-52-7	µg/kg	nc		7,800,000	NS	7,800,000	SOM01.2 Low Soil	170
1,1-Biphenyl	92-52-4	µg/kg	nc		51,000	NS	51,000	SOM01.2 Low Soil	170
Bis(2-chloroethoxy)methane	111-91-1	µg/kg	-		180,000	NS	180,000	SOM01.2 Low Soil	170
Bis(2-chloroethyl)ether	111-44-4	µg/kg	c		210	NS	210	SOM01.2 Low Soil	170
Bis(2-chloroisopropyl) ether	108-60-1	µg/kg	c		4,600	NS	4,600	SOM01.2 Low Soil	170
Bis(2-ethylhexyl) phthalate	117-81-7	µg/kg	c		35,000	100	100	SOM01.2 Low Soil	170
4-Bromophenyl phenyl ether	101-55-3	µg/kg	-	280	NS	NS	280	SOM01.2 Low Soil	170
Butyl benzyl phthalate	85-68-7	µg/kg	c		260,000	NS	260,000	SOM01.2 Low Soil	170
Carbazole	86-74-8	µg/kg	c	230,000	NS	NS	230,000	SOM01.2 Low Soil	170
Caprolactum	105-60-2		nc		31,000,000		31,000,000	SOM01.2 Low Soil	170
4-Chloro-3-methylphenol (p-chloro-m-Cresol)	59-50-7	µg/kg	nc		6,100,000	NS	6,100,000	SOM01.2 Low Soil	170
4-Chloroaniline	106-47-8	µg/kg	c		2,400	NS	2,400	SOM01.2 Low Soil	170
2-Chloronaphthalene	91-58-7	µg/kg	nc		6,300,000	NS	6,300,000	SOM01.2 Low Soil	170
2-Chlorophenol	95-57-8	µg/kg	nc		390,000	55	55	SOM01.2 Low Soil	170
4-Chlorophenyl phenyl ether	7005-72-3	µg/kg	-	160	NS	NS	160	SOM01.2 Low Soil	170
Dibenzofuran	132-64-9	µg/kg	nc		78,000	5,100	5,100	SOM01.2 Low Soil	170
3,3-Dichlorobenzidine	91-94-1	µg/kg	c		1,100	NS	1,100	SOM01.2 Low Soil	170
2,4-Dichlorophenol	120-83-2	µg/kg	nc		180,000	10	10	SOM01.2 Low Soil	170
Diethyl phthalate	84-66-2	µg/kg	nc		49,000,000	530	530	SOM01.2 Low Soil	170
2,4-Dimethylphenol	105-67-9	µg/kg	nc		1,200,000	NS	1,200,000	SOM01.2 Low Soil	170
4,6-Dinitro-2-methylphenol (4,6-Dinitro-o-cresol)	534-52-1	µg/kg	-		4,900	NS	4,900	SOM01.2 Low Soil	330
2,4-Dinitrophenol	51-28-5	µg/kg	nc		120,000	NS	120,000	SOM01.2 Low Soil	330
2,4-Dinitrotoluene	121-14-2	µg/kg	nc		1,600	NS	1,600	SOM01.2 Low Soil	170
2,6-Dinitrotoluene	606-20-2	µg/kg	c		61,000	NS	61,000	SOM01.2 Low Soil	170
Dimethyl phthalate	131-11-3	µg/kg	nc	53,000,000	NS	1,000	1,000	SOM01.2 Low Soil	170
Di-n-butyl phthalate	84-74-2	µg/kg	nc	6,200,000	6,100,000	110	110	SOM01.2 Low Soil	170
Di-n-octyl phthalate	117-84-0	µg/kg	nc	2,600,000	730,000	100	100	SOM01.2 Low Soil	170
Hexachlorobenzene	118-74-1	µg/kg	c		300	1.4	1.4	SOM01.2 Low Soil	170
Hexachlorobutadiene	87-68-3	µg/kg	c		6,200	NS	6,200	SOM01.2 Low Soil	170
Hexachlorocyclopentadiene	77-47-4	µg/kg	nc		370,000	NS	370,000	SOM01.2 Low Soil	170
Hexachloroethane	67-72-1	µg/kg	c		12,000	NS	12,000	SOM01.2 Low Soil	170
Isophorone	78-59-1	µg/kg	c		510,000	NS	510,000	SOM01.2 Low Soil	170
2-Methylphenol	95-48-7	µg/kg	c		3,100,000	500	500	SOM01.2 Low Soil	170
3- & 4-Methylphenols	15831-10-4	µg/kg	c		3,100,000	5.1	5.1	SOM01.2 Low Soil	170
2-Nitroaniline	88-74-4	µg/kg	nc	14,000	610,000	NS	610,000	SOM01.2 Low Soil	330

TABLE A-4. REFERENCE LIMITS AND PROJECT ACTION LIMITS FOR SEDIMENT
FALCON REFINERY SUPERFUND SITE

Analyte	CASRN	Units	c/nc	TCEQ TRRP Residential ¹ TotSoil Comb	USEPA Regional Screening Level ²	Protection of Benthic Invertebrates Screening Level ³	Applicable Screening Criteria ⁴	Analytical Method*	CLP CRQL
3-Nitroaniline	99-09-2	µg/kg	-	15,000	NS	NS	15,000	SOM01.2 Low Soil	330
4-Nitroaniline	100-01-6	µg/kg	c	220,000	24,000	NS	24,000	SOM01.2 Low Soil	330
Nitrobenzene	98-95-3	µg/kg	c	66,000	4,800	NS	4,800	SOM01.2 Low Soil	170
2-Nitrophenol	88-75-5	µg/kg	-	130,000	NS	NS	130,000	SOM01.2 Low Soil	170
4-Nitrophenol	100-02-7	µg/kg	-	130,000	NS	NS	130,000	SOM01.2 Low Soil	330
N-Nitrosodi-n-propylamine	621-64-7	µg/kg	c	400	69	NS	69	SOM01.2 Low Soil	170
N-Nitrosodiphenylamine	86-30-6	µg/kg	c	570,000	99,000	NS	99,000	SOM01.2 Low Soil	170
Pentachlorophenol	87-86-5	µg/kg	c		890	10	10	SOM01.2 Low Soil by SIM	6.7
Phenol	108-95-2	µg/kg	nc		18,000,000	48	48	SOM01.2 Low Soil	170
1,2,4,5-Tetrachlorobenzene	95-94-3	µg/kg	nc		18,000		18,000	SOM01.2 Low Soil	170
2,3,4,6-Tetrachlorophenol	58-90-2	µg/kg	nc		1,800		1,800	SOM01.2 Low Soil	170
2,4,5-Trichlorophenol	95-95-4	µg/kg	nc		6,100,000	10	10	SOM01.2 Low Soil	170
2,4,6-Trichlorophenol	88-06-2	µg/kg	c		44,000	10	10	SOM01.2 Low Soil	170
Polycyclic Aromatic Hydrocarbons									
Acenaphthene	83-32-9	µg/kg	nc	3,000,000	3,400,000	6.7	6.7	SOM01.2 Low Soil by SIM	3.3
Acenaphthylene	208-96-8	µg/kg	nc	3,800,000	NS	5.9	5.9	SOM01.2 Low Soil by SIM	3.3
Anthracene	120-12-7	µg/kg	nc	18,000,000	17,000,000	57	57	SOM01.2 Low Soil by SIM	3.3
Benzo(a)anthracene	56-55-3	µg/kg	c	5,700	150	108	108	SOM01.2 Low Soil by SIM	3.3
Benzo(b)fluoranthene	205-99-2	µg/kg	c	5,700	150	NS	150	SOM01.2 Low Soil by SIM	3.3
Benzo(k)fluoranthene	207-08-9	µg/kg	c	5,700	1,500	27	27	SOM01.2 Low Soil by SIM	3.3
Benzo(g,h,i)perylene	191-24-2	µg/kg	nc	1,800,000	NS	170	170	SOM01.2 Low Soil	170
Benzo(a)pyrene	50-32-8	µg/kg	c	560	15	150	150	SOM01.2 Low Soil by SIM	3.3
Chrysene	218-01-9	µg/kg	c	560,000	15,000	166	166	SOM01.2 Low Soil by SIM	3.3
Dibenz(a,h)anthracene	53-70-3	µg/kg	c	550	15	33	33	SOM01.2 Low Soil by SIM	3.3
Fluoranthene	206-44-0	µg/kg	nc	2,300,000	2,300,000	423	423	SOM01.2 Low Soil	170
Fluorene	86-73-7	µg/kg	nc	2,300,000	2,300,000	77	77	SOM01.2 Low Soil by SIM	3.3
Indeno(1,2,3-cd)pyrene	193-39-5	µg/kg	c	5,700	150	17	17	SOM01.2 Low Soil by SIM	3.3
2-Methylnaphthalene	91-57-6	µg/kg	nc	250,000	230,000	NS	230,000	SOM01.2 Low Soil	170
Naphthalene	91-20-3	µg/kg	c	220,000	3,600	176	176	SOM01.2 Low Soil	170
Phenanthrene	85-01-8	µg/kg	nc	1,700,000	NS	204	204	SOM01.2 Low Soil	170
Pyrene	129-00-0	µg/kg	nc	1,700,000	1,700,000	195	195	SOM01.2 Low Soil	170
Total Metals									
Aluminum	7429-90-5	mg/kg	nc	65,000	77,000	25,500	25,500	ISM01.3 ICP-AES	20
Antimony	7440-36-0	mg/kg	nc	15	31	3.0	3.0	ISM01.3 ICP-AES	6
Arsenic	7440-38-2	mg/kg	c	24	0.39	9.79	9.79	ISM01.3 ICP-AES	1
Barium	7440-39-3	mg/kg	nc	8,100	15,000	NS	15,000	ISM01.3 ICP-AES	20
Beryllium	7440-41-7	mg/kg	c	38	160	NS	160	ISM01.3 ICP-AES	0.5
Cadmium	7440-43-9	mg/kg	c	52	70	0.99	0.99	ISM01.3 ICP-AES	0.5
Calcium	7440-70-2	mg/kg	-	1,000,000	NS	NS	1,000,000	ISM01.3 ICP-AES	500
Chromium	7440-47-3	mg/kg	nc	Cr III = 33,000 Cr VI = 120 Cr Total =33,000	Cr VI = 0.29	Cr III or IV = 43.4	43.4	ISM01.3 ICP-AES	1
Cobalt	7440-48-4	mg/kg	nc	21	23	50	50	ISM01.3 ICP-AES	5
Copper	7440-50-8	mg/kg	nc	550	3,100	32	32	ISM01.3 ICP-AES	2.5

TABLE A-4. REFERENCE LIMITS AND PROJECT ACTION LIMITS FOR SEDIMENT
FALCON REFINERY SUPERFUND SITE

Analyte	CASRN	Units	c/nc	TCEQ TRRP Residential ¹ TotSoil Comb	USEPA Regional Screening Level ²	Protection of Benthic Invertebrates Screening Level ³	Applicable Screening Criteria ⁴	Analytical Method*	CLP CRQL
Iron	7439-89-6	mg/kg	nc	1,000,000	55,000	20,000	20,000	ISM01.3 ICP-AES	10
Lead	7439-92-1	mg/kg	-	500	400	36	36	ISM01.3 ICP-AES	1
Magnesium	7439-95-4	mg/kg	-	1,000,000	NS	NS	1,000,000	ISM01.3 ICP-AES	500
Manganese	7439-96-5	mg/kg	nc	3,700	1,800	460	460	ISM01.3 ICP-AES	1.5
Mercury	7439-97-6	mg/kg	nc	3.6	10	0.18	0.18	ISM01.3 CVAA	0.1
Nickel	7440-02-0	mg/kg	nc	840	1,500	23	23	ISM01.3 ICP-AES	4
Potassium	7440-09-7	mg/kg	-	1,000,000	NS	NS	1,000,000	ISM01.3 ICP-AES	500
Selenium	7782-49-2	mg/kg	nc	310	390	NS	390	ISM01.3 ICP-AES	3.5
Silver	7440-22-4	mg/kg	nc	97	390	0.50	0.50	ISM01.3 ICP-AES	1
Sodium	7440-23-5	mg/kg	-	1,000,000	NS	NS	1,000,000	ISM01.3 ICP-AES	500
Thallium	7440-28-0	mg/kg	nc	6.3	0.78	NS	0.78	ISM01.3 ICP-AES	2.5
Vanadium	7440-62-2	mg/kg	nc	76	390	NS	390	ISM01.3 ICP-AES	5
Zinc	7440-66-6	mg/kg	nc	9,900	23,000	121	121	ISM01.3 ICP-AES	6
<div>Notes:</div> <div>CRQLs in red cells are above the action level</div> <div>* Analytical methods were chosen based on the action level for the analyte in an attempt to ensure the CRQL is lower than the action level.</div> <div>c - carcinogenic; nc - noncarcinogenic</div> <div>¹ TCEQ TRRP Table 1 Tier 1 Residential Soil PCLs, June 29, 2012</div> <div>² USEPA November 2012 RSLs as presented at the following website at http://www.epa.gov/region9/superfund/prg/.</div> <div>³ Benthic protection based on the NOAA SQuIRTS values listed in Buchman (2008), consensus-based unless not available, otherwise the lowest of listed screening values are presented.</div> <div>⁴ Applicable Screening Criteria are the benthic protection based on the NOAA SQuIRTS Values. If those do not exist, then EPA RSL. If RSLs do not exist, then TCEQ TRRP Residential Soil PCL values.</div> <div>µg/kg = microgram(s) per kilogram</div> <div>mg/kg = milligram(s) per kilogram.</div> <div>CASRN = Chemical Abstracts Service Registry Number</div> <div>CLP = Contract Laboratory Program</div> <div>CRQL = Contract Required Quantitation Limit</div> <div>CVAA = cold vapor atomic absorption</div> <div>DL = detection limit</div> <div>HQ - hazard quotient</div> <div>ICP-AES = inductively coupled plasma-atomic emission spectroscopy</div> <div>NOAA = National Oceanic and Atmospheric Administration</div> <div>NS = not specified</div> <div>PCL = protective concentration level</div> <div>RSL = regional screening level</div> <div>SIM = selected ion monitoring</div> <div>SQuIRT = Screening Quick Reference Tables</div> <div>TCEQ = Texas Commission on Environmental Quality</div> <div>TRRP = Texas Risk Reduction Program</div> <div>USEPA = U.S. Environmental Protection Agency</div>									

TABLE A-5 REFERENCE LIMITS FOR CONTAMINANTS IN FISH TISSUE FALCON REFINING SUPERFUND SITE			
Analyte	CASRN	Units	Safety Levels
Organochlorine Pesticides			
Aldrin	309-00-2	ppm	0.3
alpha-BHC	319-84-6	ppm	
beta-BHC	319-85-7	ppm	
delta-BHC	319-86-8	ppm	
gamma-BHC (Lindane)	58-89-9	ppm	
alpha-Chlordane	5103-71-9	ppm	0.3
gamma-Chlordane	5103-74-2	ppm	0.3
4,4-DDD	72-54-8	ppm	
4,4-DDE	72-55-9	ppm	5
4,4-DDT	50-29-3	ppm	5
Total DDTs	NA	ppm	
Dieldrin	60-57-1	ppm	0.3
Endosulfan I	959-98-8	ppm	
Endosulfan II	33213-65-9	ppm	
Endosulfan sulfate	1031-07-8	ppm	
Endrin	72-20-8	ppm	
Endrin aldehyde	7421-93-4	ppm	
Endrin ketone	53494-70-5	ppm	
Heptachlor	76-44-8	ppm	0.3
Heptachlor epoxide	1024-57-3	ppm	0.3
Methoxychlor	72-43-5	ppm	
Toxaphene	8001-35-2	ppm	
Polychlorinated Biphenyls (PCBs)			
Aroclor 1016	12674-11-2	ppm	
Aroclor 1221	11104-28-2	ppm	
Aroclor 1232	11141-16-5	ppm	
Aroclor 1242	53469-21-9	ppm	
Aroclor 1248	12672-79-6	ppm	
Aroclor 1254	11097-69-1	ppm	
Aroclor 1260	11096-82-5	ppm	
Total PCBs	1336-36-3	ppm	2
Notes: Source = Safety Levels for Fish and Fishery Products Hazards and Controls Guidance = Fourth Edition (United States Food and Drug Administration 2011) CASRN = Chemical Abstracts Service Registry Number ppm = parts per million			

Appendix B

Systematic sampling locations for comparing a mean with a fixed threshold (parametric)

Summary

This report summarizes the sampling design, associated statistical assumptions, as well as general guidelines for conducting post-sampling data analysis. Sampling plan components presented here include how many sampling locations to choose and where within the sampling area to collect those samples. The type of medium to sample (i.e., soil, groundwater, etc.) and how to analyze the samples (in-situ, fixed laboratory, etc.) are addressed in other sections of the sampling plan.

The following table summarizes the sampling design. A figure that shows sampling locations in the field and a table that lists sampling location coordinates are also provided below.

SUMMARY OF SAMPLING DESIGN	
Primary Objective of Design	Compare a site mean to a fixed threshold
Type of Sampling Design	Parametric
Sample Placement (Location) in the Field	Systematic with a random start location
Working (Null) Hypothesis	The mean value at the site exceeds the threshold
Formula for calculating number of sampling locations	Student's t-test
Calculated total number of samples	10
Number of samples on map ^a	10
Number of selected sample areas ^b	1
Specified sampling area ^c	1874440.39 ft ²
Size of grid / Area of grid cell ^d	465.233 feet / 187444 ft ²
Grid pattern	Triangular
Total cost of sampling ^e	\$6,000.00

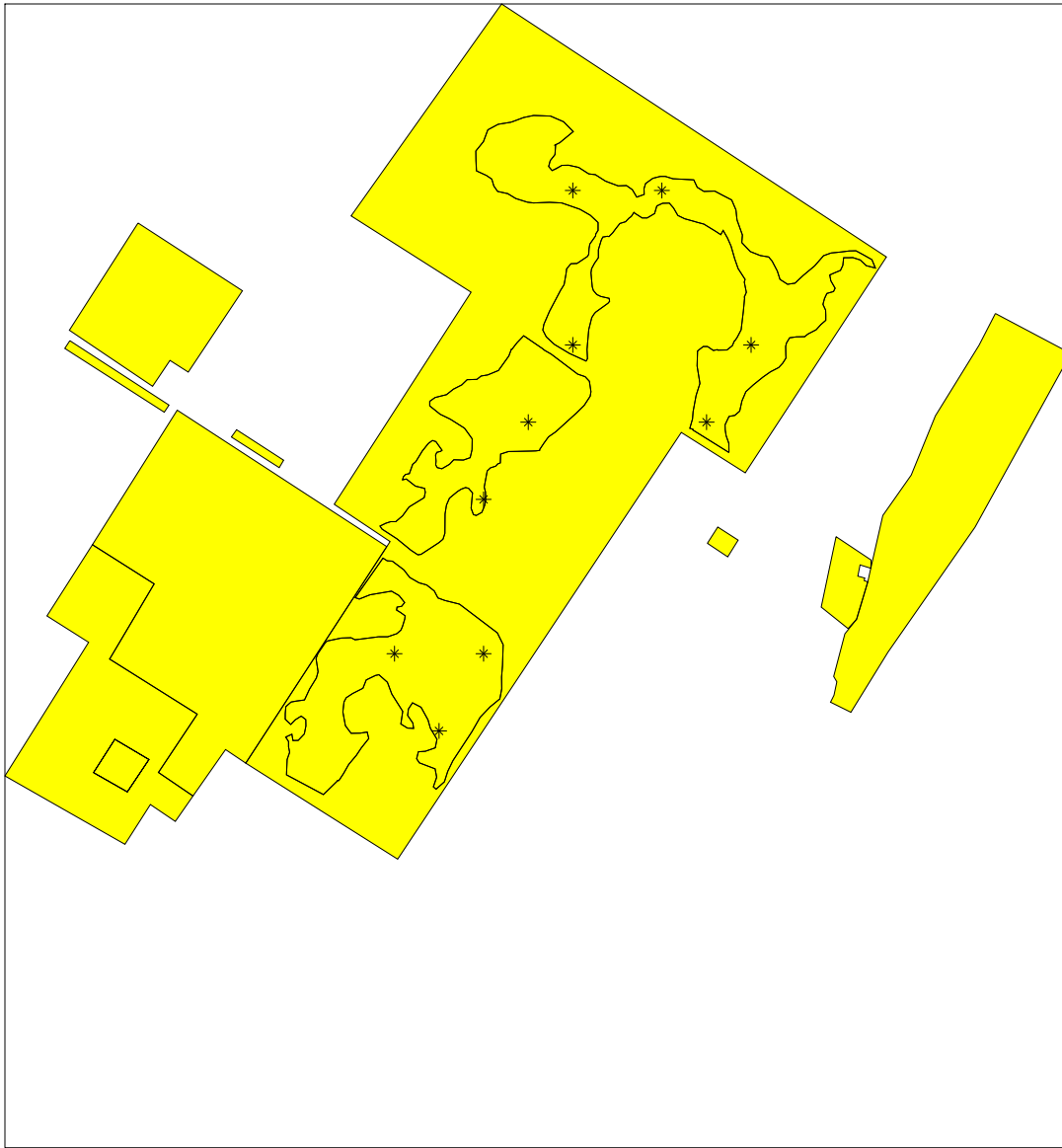
^a This number may differ from the calculated number because of 1) grid edge effects, 2) adding judgment samples, or 3) selecting or unselecting sample areas.

^b The number of selected sample areas is the number of colored areas on the map of the site. These sample areas contain the locations where samples are collected.

^c The sampling area is the total surface area of the selected colored sample areas on the map of the site.

^d Size of grid / Area of grid cell gives the linear and square dimensions of the grid used to systematically place samples.

^e Including measurement analyses and fixed overhead costs. See the Cost of Sampling section for an explanation of the costs presented here.



Area: AOC-3 IW

X Coord	Y Coord	Label	Value	Type	Historical
1412332.4403	17202300.9741			Systematic	
1412099.8238	17202703.8777			Systematic	
1412565.0568	17202703.8777			Systematic	
1412565.0568	17203509.6849			Systematic	
1412797.6733	17203912.5885			Systematic	
1413728.1393	17203912.5885			Systematic	
1413030.2898	17204315.4921			Systematic	
1413960.7558	17204315.4921			Systematic	
1413030.2898	17205121.2992			Systematic	
1413495.5228	17205121.2992			Systematic	

Primary Sampling Objective

The primary purpose of sampling at this site is to compare a mean value of a site with a fixed threshold. The working

hypothesis (or 'null' hypothesis) is that the mean value at the site is equal to or exceeds the threshold. The alternative hypothesis is that the mean value is less than the threshold. VSP calculates the number of samples required to reject the null hypothesis in favor of the alternative hypothesis, given a selected sampling approach and inputs to the associated equation.

Selected Sampling Approach

A parametric systematic sampling approach with a random start was used to determine the number of samples and to specify sampling locations. A parametric formula was chosen because the conceptual model and historical information (e.g., historical data from this site or a very similar site) indicate that parametric assumptions are reasonable. These assumptions will be examined in post-sampling data analysis.

Both parametric and non-parametric approaches rely on assumptions about the population. However, non-parametric approaches typically require fewer assumptions and allow for more uncertainty about the statistical distribution of values at the site. The trade-off is that if the parametric assumptions are valid, the required number of samples is usually less than the number of samples required by non-parametric approaches.

Locating the sample points over a systematic grid with a random start ensures spatial coverage of the site. Statistical analyses of systematically collected data are valid if a random start to the grid is used. One disadvantage of systematically collected samples is that spatial variability or patterns may not be discovered if the grid spacing is large relative to the spatial patterns.

Number of Total Samples: Calculation Equation and Inputs

The equation used to calculate the number of samples is based on a Student's t-test. For this site, the null hypothesis is rejected in favor of the alternative hypothesis if the sample mean is sufficiently smaller than the threshold. The number of samples to collect is calculated so that 1) there will be a high probability (1-β) of rejecting the null hypothesis if the alternative hypothesis is true and 2) a low probability (α) of rejecting the null hypothesis if the null hypothesis is true.

The formula used to calculate the number of samples is:

$$n = \frac{S^2}{\Delta^2} \left(Z_{1-\alpha} + Z_{1-\beta} \right)^2 + 0.5 Z_{1-\alpha}^2$$

where

- n* is the number of samples,
- S* is the estimated standard deviation of the measured values including analytical error,
- Δ is the width of the gray region,
- α is the acceptable probability of incorrectly concluding the site mean is less than the threshold,
- β is the acceptable probability of incorrectly concluding the site mean exceeds the threshold,
- $Z_{1-\alpha}$ is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\alpha}$ is 1-α,
- $Z_{1-\beta}$ is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\beta}$ is 1-β.

The values of these inputs that result in the calculated number of sampling locations are:

Analyte	n	Parameter					
		S	Δ	α	β	$Z_{1-\alpha}$ ^a	$Z_{1-\beta}$ ^b
Chemical	10	1	1	0.05	0.1	1.64485	1.28155

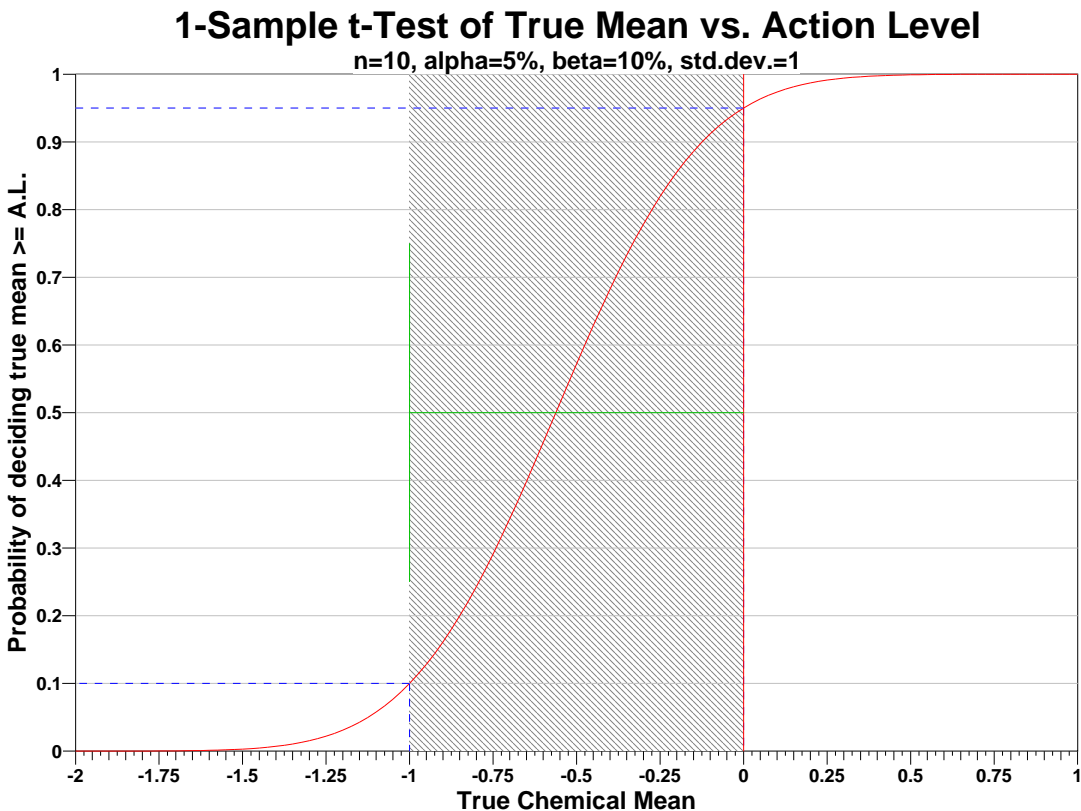
^a This value is automatically calculated by VSP based upon the user defined value of α.

^b This value is automatically calculated by VSP based upon the user defined value of β.

The following figure is a performance goal diagram, described in EPA's QA/G-4 guidance (EPA, 2000). It shows the probability of concluding the sample area is dirty on the vertical axis versus a range of possible true mean values for the site on the horizontal axis. This graph contains all of the inputs to the number of samples equation and pictorially represents the calculation.

The red vertical line is shown at the threshold (action limit) on the horizontal axis. The width of the gray shaded area is equal to Δ; the upper horizontal dashed blue line is positioned at 1-α on the vertical axis; the lower horizontal dashed blue line is positioned at β on the vertical axis. The vertical green line is positioned at one standard deviation below the

threshold. The shape of the red curve corresponds to the estimates of variability. The calculated number of samples results in the curve that passes through the lower bound of Δ at β and the upper bound of Δ at $1-\alpha$. If any of the inputs change, the number of samples that result in the correct curve changes.



Statistical Assumptions

The assumptions associated with the formulas for computing the number of samples are:

1. the sample mean is normally distributed (this happens if the data are roughly symmetric or the sample size is more than 30; for extremely skewed data sets, additional samples may be required for the sample mean to be normally distributed),
2. the variance estimate, S^2 , is reasonable and representative of the population being sampled,
3. the population values are not spatially or temporally correlated, and
4. the sampling locations will be selected probabilistically.

The first three assumptions will be assessed in a post data collection analysis. The last assumption is valid because the gridded sample locations were selected based on a random start.

Sensitivity Analysis

The sensitivity of the calculation of number of samples was explored by varying the lower bound of gray region (% of action level), beta (%), probability of mistakenly concluding that $\mu >$ action level and alpha (%), probability of mistakenly concluding that $\mu <$ action level. The following table shows the results of this analysis.

Number of Samples				
AL=0		α=5	α=10	α=15
LBGR=90	β=5	1	1	1
	β=10	1	1	1
	β=15	1	1	1
LBGR=80	β=5	1	1	1
	β=10	1	1	1
	β=15	1	1	1

LBGR=70	β=5	1	1	1
	β=10	1	1	1
	β=15	1	1	1

LBGR = Lower Bound of Gray Region (% of Action Level)
 β = Beta (%), Probability of mistakenly concluding that μ > action level
 α = Alpha (%), Probability of mistakenly concluding that μ < action level
 AL = Action Level (Threshold)

Cost of Sampling

The total cost of the completed sampling program depends on several cost inputs, some of which are fixed, and others that are based on the number of samples collected and measured. Based on the numbers of samples determined above, the estimated total cost of sampling and analysis at this site is \$6,000.00, which averages out to a per sample cost of \$600.00. The following table summarizes the inputs and resulting cost estimates.

COST INFORMATION			
Cost Details	Per Analysis	Per Sample	10 Samples
Field collection costs		\$100.00	\$1,000.00
Analytical costs	\$400.00	\$400.00	\$4,000.00
Sum of Field & Analytical costs		\$500.00	\$5,000.00
Fixed planning and validation costs			\$1,000.00
Total cost			\$6,000.00

Data Analysis for Chemical

The following data points were entered by the user for analysis.

Chemical										
Rank	1	2	3	4	5	6	7	8	9	10
0	0.046	0.0465	0.047	0.0479	0.048	0.0483	0.0485	0.0485	0.0485	0.049
10	0.0495	0.0495	0.0498	0.05	0.05	0.05	0.05	0.0525	0.055	0.055
20	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.06	0.06	0.065
30	0.065	0.065	0.065	0.075	0.085	0.095	0.1	0.136	0.153	0.215
40	0.342	0.408	0.444	0.729						

SUMMARY STATISTICS for Chemical	
n	44
Min	0.046
Max	0.729
Range	0.683
Mean	0.1031
Median	0.055
Variance	0.017642
StdDev	0.13282
Std Error	0.020024
Skewness	3.3692

Interquartile Range				0.023				
Percentiles								
1%	5%	10%	25%	50%	75%	90%	95%	99%
0.046	0.04663	0.04795	0.0495	0.055	0.0725	0.2785	0.435	0.729

Outlier Test

Rosner's test for multiple outliers was performed to test whether the most extreme value is a statistical outlier. The test was conducted at the 5% significance level.

Data should not be excluded from analysis solely on the basis of the results of this or any other statistical test. If any values are flagged as possible outliers, further investigation is recommended to determine whether there is a plausible explanation that justifies removing or replacing them.

In using Rosner's test to detect up to 1 outlier, a test statistic R_1 is calculated, and compared with a critical value C_1 to test the hypothesis that there is one outlier in the data.

ROSNER'S OUTLIER TEST for Chemical			
k	Test Statistic R_k	5% Critical Value C_k	Significant?
1	4.712	3.08	Yes

The test statistic 4.712 exceeded the corresponding critical value, therefore that test is significant and we conclude that the most extreme value is an outlier at the 5% significance level.

SUSPECTED OUTLIERS for Chemical	
1	0.729

A normal distribution test indicated that the data do not appear to be normally distributed, so further investigation is recommended before using the results of this test. Because Rosner's test can be used only when the data without the suspected outlier are approximately normally distributed, a Shapiro-Wilk test for normality was performed at a 5% significance level.

NORMAL DISTRIBUTION TEST (excluding outliers)	
Shapiro-Wilk Test Statistic	0.4909
Shapiro-Wilk 5% Critical Value	0.943

The calculated Shapiro-Wilk test statistic is less than the 5% Shapiro-Wilk critical value, so the test rejects the hypothesis that the data are normal and concludes that the data, excluding the most extreme value, do not appear to follow a normal distribution at the 5% level of significance. Rosner's test may not be appropriate if the assumption of normally distributed data is not justified for this data set. Examine the Q-Q plot displayed below to further assess the normality of the data.

Data Plots for Chemical

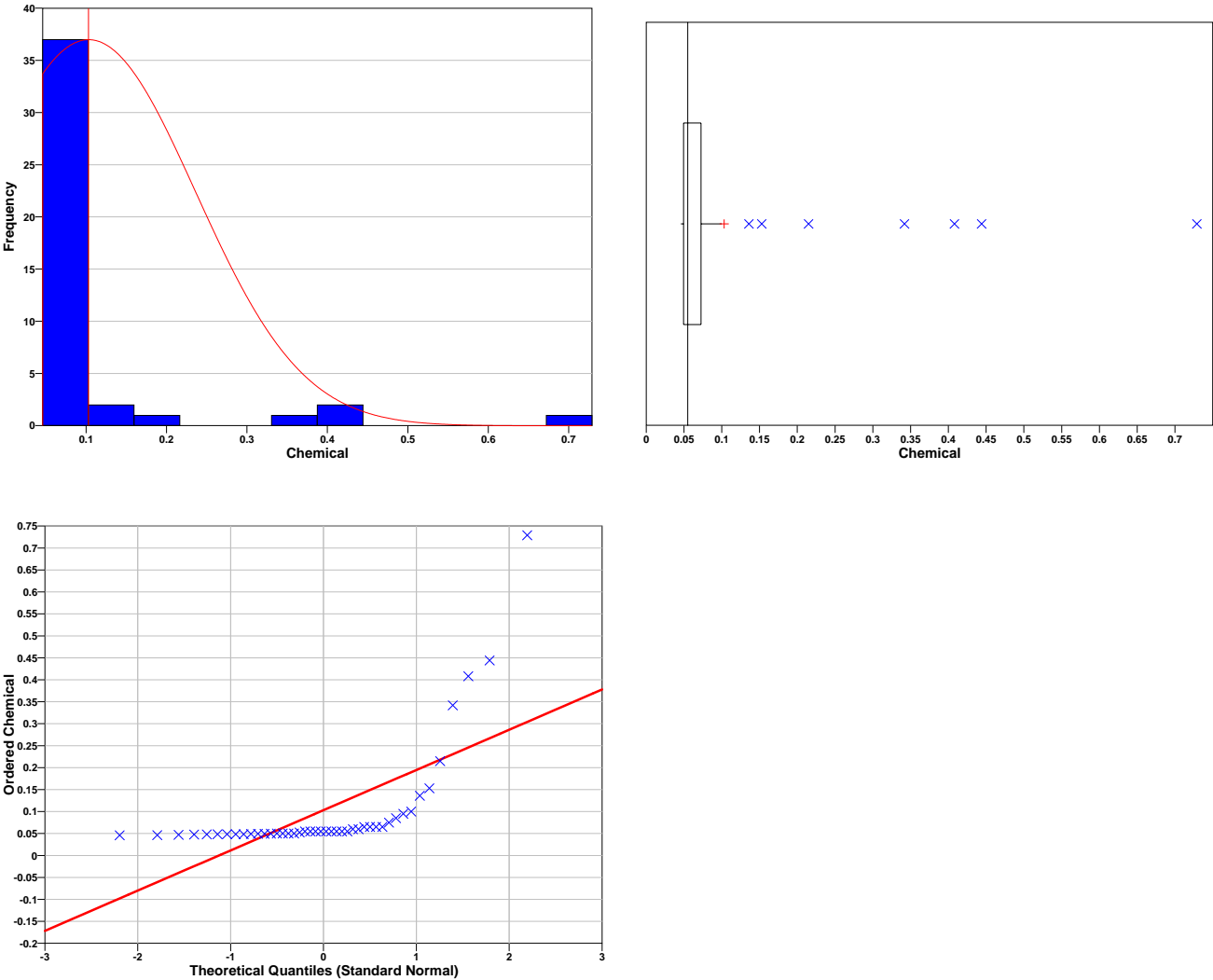
Graphical displays of the data are shown below.

The Histogram is a plot of the fraction of the n observed data that fall within specified data "bins." A histogram is generated by dividing the x axis (range of the observed data values) into "bins" and displaying the number of data in each bin as the height of a bar for the bin. The area of the bar is the fraction of the n data values that lie within the bin. The sum of the fractions for all bins equals one. A histogram is used to assess how the n data are distributed (spread) over their range of values. If the histogram is more or less symmetric and bell shaped, then the data may be normally distributed.

The Box and Whiskers plot is composed of a central box divided by a line, and with two lines extending out from the box, called the "whiskers". The line through the box is drawn at the median of the n data observed. The two ends of the box represent the 25th and 75th percentiles of the n data values, which are also called the lower and upper quartiles, respectively, of the data set. The sample mean (mean of the n data) is shown as a "+" sign. The upper whisker extends to

the largest data value that is less than the upper quartile plus 1.5 times the interquartile range (upper quartile minus the lower quartile). The lower whisker extends to the smallest data value that is greater than the lower quartile minus 1.5 times the interquartile range. Extreme data values (greater or smaller than the ends of the whiskers) are plotted individually as blue Xs. A Box and Whiskers plot is used to assess the symmetry of the distribution of the data set. If the distribution is symmetrical, the box is divided into two equal halves by the median, the whiskers will be the same length, and the number of extreme data points will be distributed equally on either end of the plot.

The Q-Q plot graphs the quantiles of a set of n data against the quantiles of a specific distribution. We show here only the Q-Q plot for an assumed normal distribution. The p^{th} quantile of a distribution of data is the data value, x_n , for which a fraction p of the distribution is less than x_n . If the data plotted on the normal distribution Q-Q plot closely follow a straight line, even at the ends of the line, then the data may be assumed to be normally distributed. If the data points deviate substantially from a linear line, then the data are not normally distributed.



For more information on these plots consult Guidance for Data Quality Assessment, EPA QA/G-9, pgs 2.3-1 through 2.3-12. (<http://www.epa.gov/quality/qa-docs.html>).

Tests for Chemical

A goodness-of-fit test was performed to test whether the data set had been drawn from an underlying normal distribution. The Shapiro-Wilk (SW) test was used to test the null hypothesis that the data are normally distributed. The test was conducted at the 5% significance level, i.e., the probability the test incorrectly rejects the null hypothesis was set at 0.05.

NORMAL DISTRIBUTION TEST	
Shapiro-Wilk Test Statistic	0.4804

Shapiro-Wilk 5% Critical Value	0.944
--------------------------------	-------

The calculated SW test statistic is less than the 5% Shapiro-Wilk critical value, so we can reject the hypothesis that the data are normal, or in other words the data do not appear to follow a normal distribution at the 5% level of significance. The Q-Q plot displayed above should be used to further assess the normality of the data.

Upper Confidence Limit on the True Mean

Two methods were used to compute the upper confidence limit (UCL) on the mean. The first is a parametric method that assumes a normal distribution. The second is the Chebyshev method, which requires no distributional assumption.

UCLs ON THE MEAN	
95% Parametric UCL	0.13676
95% Non-Parametric (Chebyshev) UCL	0.19039

Because the data do not appear to be normally distributed according to the goodness-of-fit test performed above, the non-parametric UCL (0.1904) may be a more accurate upper confidence limit on the true mean.

One-Sample t-Test

A one-sample t-test was performed to compare the sample mean to the action level. The null hypothesis used is that the true mean equals or exceeds the action level (AL). The t-test was conducted at the 5% significance level. The sample value t was computed using the following equation:

$$t = \frac{\bar{x} - AL}{SE}$$

where

- \bar{x} is the sample mean of the n=44 data,
- AL is the action level or threshold (0),
- SE is the standard error = (standard deviation) / (square root of n).

This t was then compared with the critical value $t_{0.95}$, where $t_{0.95}$ is the value of the t distribution with n-1=43 degrees of freedom for which the proportion of the distribution to the left of $t_{0.95}$ is 0.95. The null hypothesis will be rejected if $t < -t_{0.95}$.

ONE-SAMPLE t-TEST		
t-statistic	Critical Value $t_{0.95}$	Null Hypothesis
5.1489	1.6811	Cannot Reject

The test did not reject the null hypothesis that the mean value at the site exceeds the threshold, therefore conclude the true mean exceeds the threshold.

Because the data do not appear to be normally distributed, the MARSSIM Sign Test might be preferred over the One Sample t-Test. The following table represents the results of the MARSSIM Sign Test using the current data:

MARSSIM Sign Test		
Test Statistic (S+)	95% Critical Value	Null Hypothesis
0	27	Cannot Reject
Note: There may not be enough data to reject the null hypothesis (and conclude site is clean) with 95% confidence using the MARSSIM sign test.		

* - The report contents may have been modified or reformatted by end-user of software.